

APPLIED
MECHANICS*Reviews*A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS
AND RELATED ENGINEERING SCIENCE

REVS. 315-540

VOL. 8, NO. 2

FEBRUARY 1955

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Published Monthly by
THE AMERICAN SOCIETY OF
MECHANICAL ENGINEERS
at Easton, Pa., and edited by
Midwest Research Institute with the
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APPLIED MECHANICS

Reviews

Under the Sponsorship of

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Subscription and Production Office: The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., U.S.A.

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APPLIED MECHANICS REVIEWS

VOL. 8, NO. 2

MARTIN GOLAND Editor

FEBRUARY 1955

CONCEPTS EMPLOYED IN THE THERMODYNAMICS OF COUPLED IRREVERSIBLE FLOWS

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CLASSICAL thermodynamics provides to the science of heat transfer, definitions of temperature, and heat. Temperature is defined in terms of equality of temperature which is a condition of complete and stable equilibrium. The temperature concept, therefore, can be employed only where departures from equilibrium are not too great. Thus, the science of heat transfer is limited to processes in which gradients of potentials like temperature and pressure are not so great as to raise questions as to the meaning of the definitions of the potentials.

Heat in thermodynamics is an interaction between systems resulting from a temperature difference between them. It is generally identified through the temperature difference or through the change in state of a *reservoir* which is one of the interacting systems. A satisfactory reservoir must pass through stable states only and must not be involved in work interactions except for those whose magnitudes are fixed by the end states of the reservoir.

Heat flow in anisotropic crystals—i.e., crystals having different thermal conductivities in different directions—was the subject of empirical study during the nineteenth century. It was found that isotherms were sometimes not normal to the direction of heat flow, Fig. 1. When this occurred, the heat-flow vector Q had, of

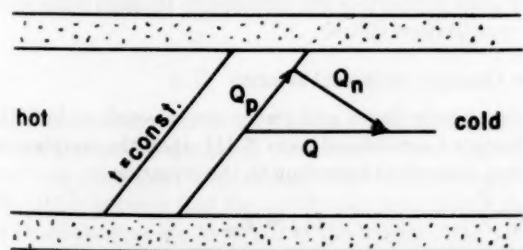


Fig. 1

course, a component Q_p in a direction parallel to the isotherm. Such a component could not be detected by means of temperature differences or gradients but had to be found in terms of the behavior of reservoirs at the boundaries of the crystal.

The heat fluxes Q_n and Q_p are coupled in that if a potential (temperature) gradient is established in the n -direction, heat flux will occur not only in the n -direction but also in the p -direction in which no potential gradient exists. It was found experimentally

that the converse was also true, namely, if a gradient is established in the p -direction, heat flux would occur in the n -direction as well as in the p -direction.

It was further deduced empirically that these fluxes could be expressed satisfactorily for moderate gradients in the form

$$Q_n = k_{nn} \frac{\partial \tau}{\partial n} + k_{np} \frac{\partial \tau}{\partial p}$$

$$Q_p = k_{pn} \frac{\partial \tau}{\partial n} + k_{pp} \frac{\partial \tau}{\partial p}$$

where τ denotes the reciprocal of the thermodynamic temperature, n and p distances in the directions n and p and the four k 's formal coefficients which may be thought of as conductivities. Experiment indicated that the coupling coefficients were equal—thus $k_{np} = k_{pn}$.

Onsager showed in 1931 (1)¹ that this reciprocal relation in the macroscopic case can be deduced from the principle of microscopic reversibility, which had long been employed in the analysis of chemical reactions. In 1945, Casimir (2) restated the argument, starting from a general macroscopic principle of symmetry which is now called the Onsager reciprocal relation. The application of this macroscopic principle has been extended to electrical conduction, relaxation phenomena, thermomechanical effects, etc., by Prigogine, De Groot, Denbigh (3), and others.

The purpose here will be to examine the one-dimensional thermomechanical effect in order to isolate and describe some of the concepts employed in the application of the reciprocal relations, and, in particular, to define some identifiable fluxes. It appears that in many instances it is either impossible or very difficult to use the thermodynamic concepts of heat and work to define heat flux and work flux.

Consider the adiabatic flow of a perfect gas through a porous barrier. If the barrier is an ordinary Joule-Thomson type of plug, then the temperature of the gas will be the same at entry and at exit and will, in fact, remain unchanged as the gas approaches and leaves the plug, as indicated by line A in Fig. 2.

Next suppose that the barrier is of a different kind, such that absorption of gas in the barrier results in a depression in temperature. This behavior would correspond to a negative "heat of absorption." The course of the temperature would now be as

¹ Numbers in parentheses indicate References at end of paper.

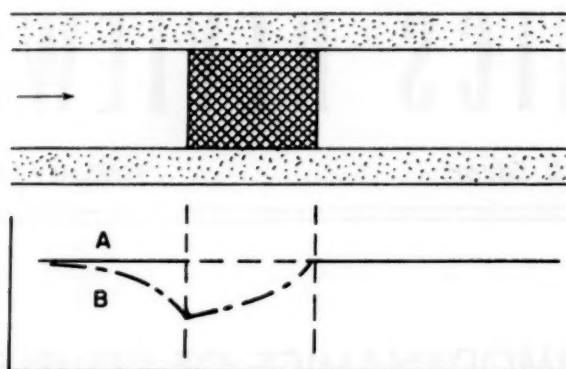


Fig. 2

shown by curve B. The temperature at exit would remain the same since, by the first law of thermodynamics, the enthalpy at exit must equal that of the undisturbed gas entering. A longitudinal heat transfer has been set up in the fluid ahead of the barrier toward the barrier face. When the fluid disengages from the barrier at the downstream face, a reverse effect occurs which brings about a rise in temperature to the original value.

DENBIGH'S ANALYSIS

K. G. Denbigh (4) has analyzed the problem of steady flow through a barrier in terms of heat flux and mass flux in the following manner:

Consider a fluid in a steady state of flow through a barrier, as shown in Fig. 3. Let the approaching fluid be maintained at temperature T by a surrounding reservoir, and let the leaving fluid be maintained at temperature $(T + dT)$ by another reser-

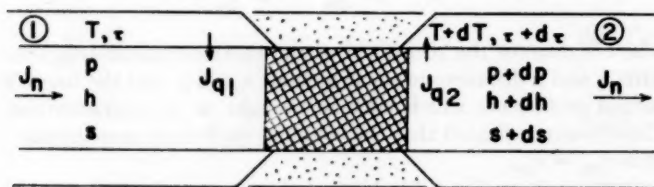


Fig. 3

voir. If the heat of absorption is negative as in Fig. 2, then a heat flux J_{q1} will be established from reservoir 1 and another J_{q2} will be established to reservoir 2. The coupling of heat flow to mass flow becomes evident here in the isothermal case ($dT = 0$). For then heat will flow out of reservoir 1 and into reservoir 2 in the absence of any temperature gradient between them. Experiment would show the inverse coupling: namely, that, if dT is not zero, mass will be transported through the barrier along with heat flow from 1 to 2, even in the absence of a pressure difference ($dp = 0$).

Analysis by means of the Onsager reciprocal relations involves five steps as follows;

I Statement of the rate of entropy generation as a sum of terms

$$\frac{dS}{dt} \equiv \dot{S} = -J_{q1}\tau + J_{q2}(\tau + d\tau) - J_n s + J_n(s + ds) \quad [1]$$

where τ denotes T^{-1} , J_n the mass flux or mass rate of flow, and the meaning of the other symbols will be clear from Fig. 3. From the first law

$$J_n h + J_{q1} = J_n(h + dh) + J_{q2}$$

so that

$$J_{q2} - J_{q1} = -J_n dh \quad [2]$$

where h denotes the enthalpy per unit mass

Simplifying Eq. [1] and substituting from Eq. [2] we get

$$\dot{S} = J_{q1}d\tau - J_n(\tau dh - ds) \quad [3]$$

Since from the first and second laws we have

$$ds = \tau dh - v\tau dp$$

it follows that

$$\dot{S} = J_{q1}d\tau - J_n v\tau dp \quad [4]$$

II Selection of conjugate fluxes and forces

From the expression for rate of entropy generation, Eq. [4], a selection of conjugate fluxes J and forces X is made, such that

$$\dot{S} = J_1 X_1 + J_2 X_2 + \dots$$

In this instance the selection may be

$$\dot{S} = J_q X_q + J_n X_n$$

where

$$X_q = d\tau \quad [5]$$

and

$$X_n = -v\tau dp \quad [6]$$

III Definition of formal coefficients or conductivities, including coupling coefficients, through linear relations

Each flux is now expressed linearly in terms of the forces; thus

$$J_q = L_{qq}X_q + L_{qn}X_n \quad [7]$$

and

$$J_n = L_{nq}X_q + L_{nn}X_n \quad [8]$$

These are defining equations for the L coefficients. They are analogous to the equations given above for the two components of heat flux in anisotropic crystals.

Some implications of the linear form can be given in the following statements which are not all independent of each other:

(a) The forces are active (not neutral)— J_q , for example, is not infinitesimal for finite $\Delta\tau$ when Δp is zero.

(b) The variation of flux with force is continuous— J_q is not finite for infinitesimal $\Delta\tau$ and Δp .

(c) $J_q \sim \Delta(\tau^n)$ for $\Delta p = 0$

where $n \neq \infty$ or 0

(d) The function $J_q(\tau)$ for $\Delta p = 0$ can be represented by a convergent series.

(e) The forces or gradients are not so great but that temperature and other properties are identifiable through some methods used for equilibrium states.

IV The Onsager reciprocal relation

When conjugate fluxes and forces are selected, as in ¶ II, and the coefficients L are defined as in ¶ III, then the coupling coefficients are symmetrical according to the equation

$$L_{nq} = L_{qn} \quad [9]$$

This is an axiom or law not deducible from the laws of classical thermodynamics. It was first stated by Onsager.

V Consideration of four special cases results in two relationships

Four special cases may be considered as follows:

$$X_q = 0, \text{ the isothermal case} \quad [a]$$

$$X_n = 0, \text{ the isopiestic case} \quad [b]$$

$$J_q = 0, \text{ the adiabatic case} \quad [c]$$

$$J_n = 0, \text{ the stationary-mass case} \quad [d]$$

From Eqs. [7] and [8] we get the following for cases [a] to [d]

$$(J_q/J_n)d\tau=0 = L_{qn}/L_{nn} \quad [a]$$

$$(J_q/J_n)dp=0 = L_{qn}/L_{nn} \quad [b]$$

$$-(X_n/X_q)J_q=0 = L_{qn}/L_{nn} \quad [c]$$

$$-(X_n/X_q)J_n=0 = L_{qn}/L_{nn} \quad [d]$$

The reciprocal relation Eq. 9 permits one to equate [a] with [d] and [b] with [c]. Thus

$$(J_q/J_n)d\tau=0 = -(X_n/X_q)J_n=0$$

which with Eqs. [5] and [6] gives

$$(J_q/J_n)d\tau=0 = v\tau(dp/d\tau)J_n=0 = -vT(dp/dT)J_n=0 \quad [10]$$

and

$$(J_q/J_n)dp=0 = -(X_n/X_q)J_q=0$$

or

$$(J_n/J_q)dp=0 = \frac{1}{v\tau}(d\tau/dp)J_q=0 = -\frac{1}{vT}(dT/dp)J_q=0 \quad [11]$$

Eq. [10] relates the heat flux induced in the isothermal case by unit mass flux to the pressure difference required to stop mass flux which would otherwise be induced by unit temperature difference. By the conventions of Fig. 3, J_q/J_n is positive if heat flux and mass flux are in the same direction, say from 1 to 2. This is the case of negative heat of absorption. From Eq. [10] it appears that if mass flux induces heat flux in the same direction, then, if dT is positive, dp must be negative to prevent mass flux.

Eq. [11] relates the mass flux to the temperature difference required to stop heat flux which would otherwise be induced by unit pressure difference. From Eq. [11] it appears that if heat flux induces mass flux in the same direction, then, if dp is negative, dT must be positive to prevent heat flux.

These results are quite general. By measuring (dp/dT) when mass flux has ceased, Denbigh has found the isothermal values of (J_q/J_n) , the "heat of transport," for CO_2 , N_2 , and H_2 in a rubber barrier. They are, respectively, -1800 , -260 , and $+100$ cal/g-mole. From kinetic theory it is known that the heat of transport of gas through pores small compared with a mean free path of the molecules is $-RT/2$ (the Knudsen effect). This information inserted into Eq. [10] yields

$$\left(\frac{dp}{dT}\right)_{J_n=0} = \frac{1}{2} \frac{p}{T}$$

or

$$p_1 T_1^{1/2} = p_2 T_2^{1/2}$$

for a finite change between states 1 and 2. The barrier could also be a mixture of gases containing constituent i and separated at each end from pure gas i by a semipermeable membrane. Then from Eq. [10] it appears that for zero flux of i the partial pressure p_i must be different at the two ends of the barrier if the temperature is different—provided that the heat of mixing of i in the mixture is not zero. This phenomenon, the Soret effect, is the basis of separation of gases by thermal diffusion.

ALTERNATIVE ANALYSIS IN TERMS OF AN ENERGY FLUX

The heat fluxes J_{q1} and J_{q2} in Denbigh's analysis were identified by means of their effect on the reservoirs 1 and 2. It may not be capacious to observe that the directions of the vectors J_q are not collinear with the direction of J_n but are actually normal to it.

The same problem may be examined without employment of

the reservoirs 1 and 2. Let the barrier of the preceding analysis be represented by B in Fig. 4. Since all properties may be assumed to be uniform in any cross section normal to the direction of mass flow, one can imagine the steady-state process in B to occur while B connects two large equilibrium regions 1 and 2 (Fig. 4). Be-

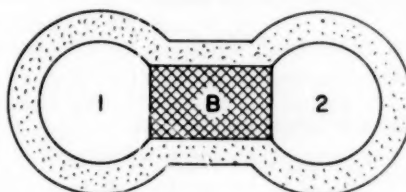


Fig. 4

cause these regions are large, their intensive properties like pressure, temperature, chemical potential, etc., are not appreciably altered by the process occurring through B, although their extensive properties like mass, energy, etc., are altered. The assumption that equilibrium prevails in regions 1 and 2 implies uniformity of intensive properties throughout each region. This can be attained by adequate circulation of the fluid in the region or by limiting the duration of the process.

If heat flux and mass flux are coupled, then it is impossible to identify the heat flux in the system of Fig. 4 by temperature gradients in B. Moreover, heat flux cannot be directly identified in terms of the change in state of one of the equilibrium regions except in the special case of zero mass flux. It may be indirectly identified by observing the change of energy of the region and subtracting from that change the quantities attributable to mass flow and the accompanying work.

In Denbigh's method, the heat flux J_{q1} was identified as the rate of decrease of the energy (or the enthalpy) of the reservoir 1. In the method illustrated by Fig. 4, the rate of decrease of the energy of the equilibrium region 1 is not a heat flux, but it may be thought of as an energy flux J_{u1} . In fact, the process in B of Fig. 4, which is identical with that in the barrier of Fig. 3, can be analyzed in terms of the mass flux J_n and the energy flux J_u as well as in terms of J_n and J_q of the previous analysis. The same steps of procedure, ¶ I to ¶ V, can be followed as shown below.

I Statement of the rate of entropy generation

For steady state in B we may write for the rate of entropy generation

$$\dot{S} = (dS_1/dt) + (dS_2/dt)$$

where subscripts 1 and 2 refer to the equilibrium regions of Fig. 4. From Gibbs' equation for a constant-volume phase in equilibrium states, we have

$$dS_1 = (dU_1/T_1) - (\mu_1/T_1)dn_1$$

where μ_1 denotes the chemical potential of the flowing substance in the phase 1, and n_1 the mass (or number of moles) of that substance in phase 1. Employing τ for $1/T$, we may express the entropy changes as

$$dS_1 = \tau(dU_1/dt) - \mu\tau(dn_1/dt)$$

$$\text{and} \quad dS_2 = (\tau + d\tau) \frac{dU_2}{dt} - [\mu\tau + d(\mu\tau)] \frac{dn_2}{dt}$$

The fluxes J_n and J_u may be defined as follows:

$$J_n \equiv (dn_2/dt) = -(dn_1/dt)$$

and

$$J_u \equiv (dU_2/dt) = -(dU_1/dt)$$

Thus, we get for the rate of entropy generation

$$\dot{S} = J_u d\tau - J_n d(\mu\tau) \quad [12]$$

where

$$d\tau = \tau_2 - \tau_1$$

and

$$d(\mu\tau) = (\mu\tau)_2 - (\mu\tau)_1$$

II Selection of conjugate fluxes and forces

$$X_u = d\tau \quad [13]$$

$$X_n = -d(\mu\tau)$$

III Linear relations and formal coefficients

$$J_u = L_{uu}X_u + L_{un}X_n$$

$$J_n = L_{nu}X_u + L_{nn}X_n$$

IV The reciprocal relation

$$L_{un} = L_{nu}$$

V The four special cases

The analogs of Eqs. [a], [b], [c], and [d] above are obvious. It is only necessary to write the analogs of Eqs. [10] and [11]

$$(J_u/J_n)_{d\tau=0} = \left[\frac{d(\mu\tau)}{d\tau} \right]_{J_n=0} \quad [14]$$

and

$$(J_n/J_u)_{d(\mu\tau)=0} = \left[\frac{d\tau}{d(\mu\tau)} \right]_{J_u=0} \quad [15]$$

The differential $d(\mu\tau)$, like the differential $d\tau$, refers to the change in the quantity in parentheses between the two ends of the barrier B; that is, the value of μ is the same at the left-hand boundary of B as in region 1. This is consistent with the tacit assumption that local equilibrium prevails between the fluid in 1 and in B. The differentials $d(\mu\tau)$ and $d\tau$ reflect the gradients in the potentials μ and τ in B.

The chemical potential μ_1 may be expressed in terms of properties of the pure fluid in region 1: thus,

$$\mu_1 = h_1 - Ts_1$$

and

$$\begin{aligned} d(\mu\tau) &= d(h\tau) - ds \\ &= h d\tau + \tau dp \end{aligned}$$

Therefore Eq. [14] becomes

$$(J_u/J_n)_{d\tau=0} - h = \tau \nu (dp/d\tau)_{J_n=0} \quad [16]$$

It can readily be shown (5) that for zero heat of absorption in the barrier

$$J_u = hJ_n$$

The excess of the decrease in U_1 per unit time over hJ_n may, therefore, be accounted for by a heat flow to the face of the barrier B. This heat-per-unit time is identical with the J_q of Denbigh's analysis; and Eq. [16] and, therefore, Eq. [14] are evidently identical with Eq. [10]. Equation [15], on the other hand, is not identical with Eq. [11]. In fact, the restrictions $d(\mu\tau) = 0$ and $J_u = 0$ which appear in Eq. [15] are more difficult to visualize than those $dp = 0$ and $J_q = 0$ which appear in Eq. [11]. It appears that Denbigh's analysis in this instance yields the simpler result, although Eqs. [14] and [15] taken together must contain the same information as Eqs. [10] and [11].

THE ENTROPY FLUX

The definition above of an energy flux vector

$$J_u = -(dU_1/dt)$$

suggests the definition of an entropy flux vector

$$J_s = -(dS_1/dt)$$

That such a vector is not independent of J_u and J_n may be seen from the Gibbs equation. Since

$$dS_1 = \tau dU_1 - \mu \tau dn_1$$

we have, upon dividing through by dt and substituting the symbols for flux vectors

$$J_{s1} = \tau J_{u1} - \mu \tau J_{n1} \quad [17]$$

This equation provides the means of eliminating either J_u or J_n from the preceding analysis.

Upon eliminating J_u , we have

$$\dot{S} = J_s X_s + J_n X_n$$

where

$$X_s = d(\ln \tau), \quad \text{and} \quad X_n = -\tau d\mu.$$

The results are

$$(J_s/J_n)_{d(\ln \tau)=0} = -(d\mu/dT)_{J_n=0} \quad [18]$$

and

$$(J_s/J_n)_{d\mu=0} = -(d\mu/dT)_{J_s=0} \quad [19]$$

It can readily be shown from Eq. [17] that Eq. [18] is equivalent to Eqs. [10] and [14].

Upon eliminating J_n we have for results

$$(J_u/J_s)_{d\mu=0} = \frac{1}{\tau} \left[1 + \frac{\mu}{\tau} \frac{d\tau}{d\mu} \right]_{J_s=0} \quad [20]$$

and

$$(J_u/J_s)_{d(\mu\tau)=0} = \frac{1}{\tau} \left[1 + \frac{\mu}{\tau} \left(\frac{d\tau}{d\mu} \right)_{J_u=0} \right] \quad [21]$$

It can readily be shown from Eq. [17] that Eq. [20] is equivalent to Eq. [19].

These examples do not exhaust the possibilities of conjugate fluxes and forces. For example, a flux TJ_s might be employed along with J_n or J_u . As another example, the flux $(J_u - hJ_n)$ might be employed along with J_n ; but since

$$J_u - hJ_n = J_q$$

this choice would be identical with Denbigh's.

THE ENTROPY FLUX AND ENTROPY GENERATION

For steady state the mass flux J_n has the same value at each end of the barrier B. The same is true for the energy flux J_u , but not for the entropy flux J_s . The increment in J_s between the left-hand and right-hand ends of B is the rate of entropy generation:

$$\begin{aligned} S &= (dS_2/dt) + (dS_1/dt) \\ &= J_{s2} - J_{s1} = dJ_s \end{aligned}$$

This is the net rate of increase of entropy in the equilibrium regions 1 and 2 as a result of the process in B.

In the nonsteady case, the difference between \dot{S} and dJ_s is the rate of increase in entropy of B. Thus

$$\begin{aligned} \dot{S} &= (dS_2/dt) + (dS_1/dt) + (dS_B/dt) \\ &= dJ_s + (dS_B/dt) \end{aligned}$$

CONCLUSION

In the preceding discussion an attempt has been made to state for the one-dimensional steady-state case the definitions and

axioms of the thermodynamics of coupled irreversible flows. Rather than rely upon the intuition of the reader, the method defines flux quantities in each instance in terms of the rate of change of an extensive property of an equilibrium region.

ACKNOWLEDGMENT

The author acknowledges with pleasure the help he has received from K. G. Denbigh, L. Tisza, and S. H. Crandall.

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Books Received for Review

BIEZENO, C. B., AND GRAMMEL, R., *Engineering dynamics*, Vol. III, Steam turbines (translated from German by Winter, E. F., and Havemann, H. A.), London, Glasgow, Blackie & Son, Ltd., 1954, 264 pp. 40 s.

BIEZENO, C. B., AND GRAMMEL, R., *Engineering dynamics*, Vol. IV, Internal-combustion engines (translated from German by White, M. P.), London, Glasgow, Blackie & Son, Ltd., 1954, ix + 282 pp. 50 s.

ERDÉLYI, A., MAGNUS, W., OBERHETTINGER, F., AND TRICOMI, F. G., *Tables of integral transforms*. Vol. II (Bateman Manuscript Project), New York, Toronto, London, McGraw-Hill Book Co., Inc., 1954, xvi + 451 pp. \$8.

HUDSON, W. G., *Conveyors and related equipment*, 3rd ed., New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, vii + 524 pp. \$9.

KETNATH, A., *Das wärmetechnische Messwesen in Dampfkraftwerken und Industrie-betrieben*, Berlin, Springer-Verlag, 1954, ix + 222 pp., 140 figs. DM 25.50.

MACHU, W., *Oberflächenvorbehandlung von Eisen- und Nichteisenmetallen*, Leipzig, Akademische Verlagsgesellschaft, 1954, xx + 801 pp., 371 figs. DM 49.

MEIXNER, J., AND SCHAFKE, F. W., *Mathieu'sche Funktionen und Sphäroidfunktionen (Grundlehren der mathematischen Wissenschaften, Bd. 71)*, Berlin, Springer-Verlag, 1954, xii + 414 pp., 29 figs. DM 49.

MORSE, P. M., AND FESHBACH, H., *Methods of theoretical physics*, Parts I, II (International Series in Pure and Applied Physics), New York, Toronto, London, McGraw-Hill Book Co., Inc., 1953, xxii + 1037 pp.; xviii + 980 pp.

MORWOOD, J., *Sailing aerodynamics*, New York, Philosophical Library, 1954, 123 pp. \$7.50.

RAUH, K., *Praktische Getriebelehre*, Bd. 2. Die Keilkette, 2nd rev. ed. (edited by Rauh, W. K.), Berlin, Springer-Verlag, 1954, vii + 172 pp., 128 pp. of figs., 4 tables. DM 43.50.

VELASCO DE PANDO, M., *Plasticidad (Nueva teoría y aplicaciones)*, Madrid, Patronato de Publicaciones de la Escuela Especial de Ingenieros Industriales, 1954, xvi + 256 pp. 130 ptas.

Theoretical and Experimental Methods

(See also Revs. 341, 352, 357, 379, 394, 447, 455)

315. Ridenour, L. N., edited by, *Modern physics for the engineer*, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1954, xi + 499 pp. \$7.50.

The present scope of engineering curricula is such that, through elimination, many pertinent topics of modern physics are forced to be overlooked. This book is a compilation of lectures given at U.C.L.A. by outstanding men in the various fields of modern physics. The reviewer feels that a junior or senior-year course with this book as a text would be invaluable to the engineer in view of the new branches in which he must work. The outstanding examples, of course, are reactor engineering and semi-conductor applications.

The first part of the book concerns itself with the laws of nature and contains solid-state physics, nuclear machines and power, and a short article on elementary particles.

The second part of the book treats environmental sciences such as astrophysics, geophysics, oceanography, and articles on atmospheric electricity and supersonic flow.

The concluding section is invaluable for communication students in electrical engineering for its excellent articles on semi-conductors and information theory. These, of course, are complemented by an article on computing machines which will give the graduating engineer an insight into the operation and the capacity of high-speed computers.

While space does not permit a more detailed review of this book, reviewer would like to comment on only two chapters of particular interest to him.

Kittel's chapter on magnetism commences with a descriptive statement on the different magnetic behaviors of solids and delves into the theoretical aspects. It is felt that a slight rearrangement of the material might better carry along the student without losing him in theoretical considerations which could be covered after the descriptive analysis on ferromagnetic domains. The remaining portion of this chapter is written in an easily readable style.

Griggs' chapter on high-pressure phenomena is to be highly recommended to those who would like to become familiar with the experimental and theoretical implications of this field. The historical survey and experimental techniques portion of this chapter give the reader an excellent feel for the difficulties involved in obtaining superpressures.

The reviewer highly recommends that this book be on the required reading list of engineering students. S. L. Levy, USA

316. Thorne, F. W., and Walshaw, A. C., *Engineering units and the Stroud convention*, London, Glasgow, Blackie & Sons, Ltd., 1954, vii + 29 pp. 3s 6d.

This booklet is for students studying applied mechanics and engineering science. Its purpose is to present a simple method of overcoming difficulties concerning units and dimensions when developing and using formulas. From the preface

317. Stoll, R. R., *Linear algebra and matrix theory*, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1952, xv + 272 pp. \$6.

Volume is designed as text for advanced undergraduates or beginning graduates. Chapter headings are: Systems of linear equations; Vector spaces; Basic operations for matrixes; Determinants; Bilinear and quadratic functions and forms; Linear transformation on a vector space; Canonical representations of a linear transformation; Unitary and Euclidean vector spaces. Book contains many results needed by applied workers, but ap-

plications to numerical analysis, integral equation, etc., are not given. The choice of notation is unfortunate as superscripts are used to designate a coordinate of a vector rather than a subscript. Author's reason for this is not convincing. Y. L. Luke, USA

318. Privalov, I. I., *Introduction to the theory of functions of a complex variable* [Vvedeniye v teoriyu funktsii kompleksnogo peremennogo], 9th ed., Moscow, Gosud. Izdat. Tekh.-Teor. Lit., 1954, 444 pp.

This is a new edition of the excellent textbook for Russian universities and technical high schools.

It is divided into 13 chapters containing 54 paragraphs and 234 subtopics. The volume begins with a short introduction about the role of complex numbers and of the theory of functions in pure and applied mathematics. Each chapter ends with numerous examples for solution; the work concludes with a detailed register of matters treated.

The object of the four initial chapters (up to p. 190) is to prepare necessary analytic equipment for mathematical research of functions of a complex variable. Remaining part of the work explains the most important facts from the theory of analytic functions. The following table of contents will give a more detailed idea of the topics covered in the book: 1. Complex numbers; 2. Complex variable and its functions; 3. Linear and other simple representations; 4. Cauchy's theorem. Cauchy's integral; 5. Series of analytic functions, development of functions into power series; 6. Isolated singularities of a single-valued function; 7. Calculus of residues; 8. Theorem of Picard; 9. Infinite products and their application to analytic functions. 10. Analytical continuation; 11. Elements of elliptic functions; 12. General principles of conformal mapping; 13. Properties of one-sheet functions (einblättrige Funktionen).

Presentation is clear, vivid, and, as usual in Russian books, abundantly provided with examples from various fields of applied mathematics and technical science. Paper is good, print careful.

Reviewer considers the volume to be very useful not only for mathematicians, but also for engineers and physicists.

V. Vodička, Czechoslovakia

319. Allen, D. N. de G., *Relaxation methods*, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1954, x + 257 pp. \$7.50.

In this book, the author sets out "to explain as clearly as possible how to relax." As a consequence, little attention is paid to various possible mathematical questions associated with the relaxation processes; instead, extensive attention is given to the exact operations to be performed in order to get numerical answers to problems.

As is usual, the book opens with a description of the basic ideas of the relaxation processes and applications to simple linear algebraic equations. The writing is very good from the point of view of making clear to a beginner what steps to take, and why. Gradually, more and more difficult problems are introduced so that a person reading the book carefully should soon be able to handle fairly advanced problems. The first two chapters on linear algebraic equations are followed by a discussion of frameworks. The author then moves into the area of differential equations; first, ordinary differential equations in chap. 4, and Laplace and Poisson equations in two dimensions in chaps. 5 and 6. Since these latter are of very frequent occurrence and introduce a number of the more advanced complexities, several chapters are devoted to them. Specifically, a clear account is given on the manner in which one may pass from a coarse to fine net and on the handling of boundary conditions given in terms of normal gradients on a curved boundary.

In succeeding chapters there are treated, both in instructions for solution and worked examples, the quasi-plane-potential equation, the biharmonic equation, simultaneous differential equations, eigenvalue problems in both algebraic equations and differential equations. The remainder of the book, chaps. 13 through 16, is devoted to a series of advanced topics treated in a very interesting and often original way. Chap. 13 deals with internal boundaries and interfaces; those problems of elasticity, fluid mechanics, etc., in which the domain is multiply connected. Chap. 14 deals with problems involving unknown boundaries. In the percolation of ground water and in free jets, in plastic torsion, and other type problems, the differential equation controlling the variable changes discontinuously across a boundary whose position is initially unknown but which is specified by an excess of boundary conditions. A number of these cases are considered. In chap. 15, nonelliptic differential equations are discussed and it is shown how to change the order of the differential equation and boundary conditions so as to solve, by relaxation methods, problems not initially in the right form. The final chap. 16 discusses three-dimensional relaxation. Only simple problems are considered, but at the end of the book the discussion is entirely adequate to start the reader off in the right direction should three-dimensional problems of interest be practically workable by this method. The book contains an excellent treatment of relaxation methods for solution of physical problems for the man who wants to know how to get the numerical value for the answer.

H. W. Emmons, USA

320. Levens, A. S., *Graphics in engineering and science*, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, viii + 696 pp. \$7.

For many persons the concept of a "graphical language" is limited to the drafting of making or building something. This is important, of course, to the engineer in training for industry and production. His direct interests are satisfied by many excellent texts on engineering drawing and descriptive geometry.

However, for the engineer in training for design and development, such a concept is much too narrow, for he finally comes to realize this "graphic language" may also be a supplement to mathematical analysis, if not indeed a form of mathematics itself. Very few books are now available having in mind this broader view.

This review is concerned with a new text that tries to correlate the fundamental ideas which should be included in this broad aspect of the matter. The material here may conveniently be considered as divided into two categories: drafting and computations.

The drafting category starts with the assumption that the student has already had a first course in engineering drawing. Then in a dozen chapters and several appendixes, it studies descriptive geometry and a number of items frequently considered as advanced engineering drawing, or rather machine drawing. The word "studies" is used advisedly here, because a complete and convenient set of "problem sheets" accompany the text. We have worked many of these problems and find they test out satisfactorily the material discussed in the text.

In the appendix dealing with geometric construction, there is a brief discussion of the Pascal and the Brianchon theorems as applied to the drafting of conic sections; but the material is not tied directly into the modern problems of aircraft lofting.

The computation category—and this is where the book seems almost unique in its scope—demonstrates graphic mathematics in three fields that are usually separated. Empirical equations and nomographs are often combined into a single course called "graphics of engineering formulas." In this instance the nomography is

taken from a book by the same author; the basis of construction here is similar—triangles rather than the third-order determinant. Another general field is graphic statics, which is really a part of applied mechanics. (There is no consideration of linear velocities and accelerations, which would be the corresponding phase in the field of kinematics.) The third field is graphic calculus, both differentiation and integration. Here again, the solution of a number of problems shows the presentation both satisfactory and convenient.

The final chapter, "Graphics of research," sums up many of the previous subjects and applies them to the field of prosthetic devices. This is an excellent demonstration of combined scientific attack on a complex problem. Its inclusion here is a fitting climax to the study of "graphical language."

It might be offered in criticism of this book that it is too voluminous, that it tries to cover too much. On the one hand, it does omit the equivalent of a first course in drafting. On the other hand, the mere inclusion of advanced material, particularly in computations, might be an inspiration to the curious student who reads beyond his assignment. C. E. Pearce, USA

321. Miller, J. C. P., edited by, *Table of binomial coefficients* (Royal Soc. Math. Tables, vol. 3), New York, Cambridge University Press, 1954, viii + 162 pp. \$6.50.

Collection can be divided into two parts. First, (n/r) is tabulated exactly for $r \leq n/2 \leq 100$. In effect this gives all values up to $n = 200$. Secondly, for various upper limits of r not exceeding 12, exact entries are given for a very large n . Tables of triangular and tetrahedral numbers, for example, continue to $n = 5000$.

Introduction describes historical background, method of evaluation, and checks employed to insure accuracy. Table is well arranged and the first page is an index to facilitate location of coefficients. Tables are useful in a wide variety of subjects, such as statistics, operations research, etc. Y. L. Luke, USA

322. Fox, L., *A short table for Bessel functions of integer orders and large arguments* (Royal Soc. Shorter Math. Tables no. 3), New York, Cambridge University Press, 1954, 28 pp. \$1.25.

In two previous volumes, tables of Bessel functions $J_n(x)$, $Y_n(x)$, $I_n(x)$, and $K_n(x)$ were given for integral values of n from 0 to 20 and x ranging from 0 to 20 or 25 [British Assoc., 1937, 1952]. Purpose of present volume is to extend these to cover interval $20 \leq x \leq \infty$ for same n .

Both $J_n(x)$ and $Y_n(x)$ can be made to depend on asymptotic expansions usually notated as $P_n(x)$ and $Q_n(x)$. Modified functions can be written as $I_n(x) = (\exp x)F_n(x)/(2\pi x)^{1/2}$; $K_n(x) = (\exp -x)G_n(x)(\pi/2x)^{1/2}$. To minimize computations and space required for tables, functions tabulated are against argument $1/x = 0(0.001)0.05$. Summary description follows: Values of $P_n(x)$ and $Q_n(x)$ to 9 d if $n < 10$, 8 d if $n \geq 10$. Modified second and fourth differences (if significant) are given for interpolation purposes. Values of $F_n(x)$ and $G_n(x)$ to 9 d for $n = 0(1)9$ and differences as above. If $n \geq 10$, F_n decreases and G_n increases rapidly so that direct tabulation is difficult. To circumvent this, natural logarithms of latter functions are given to 8 d with modified second differences.

Introduction fully describes computations and check procedures so that reader is assured tables are as accurate as claimed. Volume is worthy addition to collection of tables of Bessel functions. Y. L. Luke, USA

323. Lebedev, N. N., *Special functions and their applications* [Spetsialnyye funktsii i ich prilozheniya], Moscow, Gosud. Izdat. Tekh.-Teor. Lit., 1953, 379 pp.

Book is written for calculating engineers and physicists who are

often painfully cognizant of the scattered studies and articles on special functions of mathematical physics and techniques.

Lebedev's work fills the long-felt gap in this kind of literature. It is obviously not so voluminous as the set by Erdelyi, Magnus, Oberhettinger, and Tricomi [AMR 7, Revs. 1365, 1366], but contains, nevertheless, all that is necessary for applied workers: Bessel and spherical functions, also functions of the parabolic cylinder, etc.

The volume is divided into 10 chapters. First comes theory of the gamma function and related items. Chap. 2 is devoted to the error function; chap. 3 deals with exponential integrals and related transcendents.

Chap. 4 concerns orthogonal polynomials. Basic methods and application are exemplified on the Legendre, Hermite, and Laguerre functions. The next two main parts are devoted to the theory and use of Bessel functions; chaps. 7 and 8 have for subject spherical functions. Then comes a section on the hypergeometric functions. Book concludes with the study of the functions of the parabolic cylinder.

Chapters have a uniform structure: theory and the most important properties of the functions in question, their application, bibliography of tables for practical computation, and, finally, several examples to be solved. The work ends with a literature index.

Reviewer has not found any mention of Mathieu functions and Lamé transcendents. At least a short account of the properties of these important functions and of their application would be welcome and, in reviewer's opinion, compatible with the character of the book. It is also to be regretted that the work does not have a subject index.

Apart from the aforesaid remarks (the same relates also to elliptic functions and integrals), the book must be designated as a very successful one. We warmly recommend it to calculating engineers and physicists. V. Vodička, Czechoslovakia

324. Wax, N., edited by, *Selected papers on noise and stochastic processes*, New York, Dover Publications, Inc., 1954, 337 pp. \$2.

Book is one of a series of paperbound scientific books. It contains the following six papers on random processes. Chandrasekhar, S., Stochastic problems in physics and astronomy [from *Rev. mod. Phys.* 15, no. 1]; Uhlenbeck, G. E., and Ornstein, L. S., On the theory of the Brownian motion [ibid., 36, no. 3]; Wang, M. C., and Uhlenbeck, G. E., On the theory of the Brownian motion II [ibid., 17, nos. 2 and 3]; Rice, S. O., Mathematical analysis of random noise [from *Bell System tech. J.* 23, 24]; Kac, M., Random walk and the theory of Brownian motion [from *Amer. math. Monthly* 54, no. 7]; Doob, J. L., The Brownian movement and stochastic equations [from *Ann. Math. Princeton* 43, no. 2]. Ed.

325. Berkeš, B., *Fourier series and Laplace transforms* (in German), *Glasnik Mat.-Fiz. Astron.* (II) 8, 3, 196–212, 1953.

Author gives an extensive table of p -multiplied Laplace transforms of periodic functions, their associated Fourier series, and sketches of the corresponding wave form. Some well-known elementary systems (differentiating and integrating circuits, plucked string, low pass-filter) are examined to illustrate the usefulness of the tables. J. L. Lubkin, USA

326. Haller, J., *Laplacian integral transform and integration of partial differential equations of parabolic type* (in German), *ETH Zürich Prom. Nr.* 2227, 44 pp., 1953.

Author applies the Laplace transform to prove the equivalence between a general linear four-dimensional parabolic boundary-

value problem and a certain linear three-dimensional elliptic boundary-value problem. To establish his theorem he generalizes the method used by Zaremba for the equation $\Delta u - \lambda u = 0$ [Bull. Inter Acad. Sci. Cracov, Cl. Sci. Math. Nat., 69-167, 1905; J. Math. pures appl. (5) 8, 59-117, 1902] to equation $L(u) - \lambda u = 0$, where $L(u)$ denotes a linear general elliptic differential expression.

In the author's proof, eighteen lemmas are stated.

G. Sestini, Italy

327. Zbornik, J., Asymptotic expressions for Fresnel integrals and related functions, and their possible application for the calculation of special rocket trajectories (in German), ZAMP 5, 4, 345-351, 1954.

Paper gives asymptotic expansion for ${}_0F^s[\exp - t(k^{-1})]t^{-1/2}dt$. This is essentially the error function for complex argument. Author seems unaware of existing tables and work on subject. See, for example, P. C. Clemmow and C. M. Munford [AMR 6, Rev. 1464]. A table is also available on punched cards from National Bureau of Standards.

Y. L. Luke, USA

328. Gumbel, E. J., and Carlson, P. G., Extreme values in aeronautics, J. aero. Sci. 21, 6, 389-398, June 1954.

First part of this paper contains a brief and clear review of the characteristics and methods of application of the asymptotic extreme value probability distribution $\exp(-e^{-y})$. In the second part of the paper, authors have collected a series of applications of this distribution to observed distributions of maxima (and minima) wind speeds, atmospheric gust velocities, airplane gust accelerations, airplane maneuver accelerations, and airplane air speeds. On the basis of the reasonably good fits obtained in these applications, the authors, without qualification, advocate the use of this distribution for the fitting of observed distributions of these quantities.

In this reviewer's opinion, this unqualified recommendation is unfortunate and apt to be misleading to the aeronautical research worker. This distribution has been applied to data of the type listed for a number of years. These applications have not proved as generally successful as implied by the authors. In particular, the distribution of maximum maneuver accelerations and maximum air speeds obtained in many types of airplane operations do not appear to follow this distribution of extreme values. In reviewer's opinion, a more critical approach to the applicability and limitations of the extreme value distribution would have substantially improved this paper.

H. Press, USA

329. Bellman, R., Dynamic programming and a new formalism in the calculus of variations, Proc. nat. Acad. Sci. Wash. 40, 4, 231-235, Apr. 1954.

Dynamic programming is a mathematical theory devoted to the study of multistage processes. Bellman has successfully analyzed a number of such processes using functional equation techniques (references listed in paper reviewed). The present paper shows that such techniques may be used to treat calculus of variations problems. Two such problems are discussed: (1) maximize $\int_0^1 F(x, z) du$ subject to the constraint $dx/du = G(x, z)$, $x(0) = c$; and (2) determine the eigenvalues of the system

$$d^2x/dt^2 + \lambda\phi(t)x = 0, x(0) = x(1) = 0$$

The classical approach to a calculus of variations problem considers the integral to be maximized as a functional of the unknown function. Methods analogous to those of differential calculus then give rise to the Euler equations as necessary conditions upon the unknown function. Bellman's functional equation technique

considers the maximum value of the integral as a function of the state variables.

In problem (1), a partial differential equation is derived expressing the desired function in terms of the state variables t and c . For the case $G(x, z) = Z$, problem (1) reduces to the familiar calculus of variations problems of maximizing $\int_0^1 F(x, x') du$. In this case, the characteristic equations of the partial differential equations are equivalent to the usual Euler equations.

The eigenvalue problem (2), when formulated as a calculus of variations problem, also yields to the functional equation technique. The problem is embedded in a more general problem, which for specific values of the state variables, reduces to the problem at hand. Again the required function is expressed as the solution of a partial differential equation in the state variables.

J. O. Harrison, USA

330. Bellman, R., Some applications of the theory of dynamic programming—a review, J. Oper. Res. Soc. Amer. 2, 3, 275-288, Aug. 1954.

Purpose of this paper is to provide an expository account of the theory of dynamic programming. To illustrate the general principles, two particular problems, one of deterministic type and one of stochastic type, are treated. From author's summary

331. Beech, D. G., Experiences of correlation analysis, Appl. Statistics 2, 2, 73-85, June 1953.

Author uses some experiences in the field of ceramics as pegs on which to hang discussions of practical points that arise in correlation analysis. He deals with the dangers of extrapolation, the use of correlation analysis to test the validity of a theoretical relationship, and the estimation of a constant of proportionality from data.

From author's summary

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 320, 374)

332. Lewenson, L. B., Kinematics and dynamics of mechanisms [Kinematik und Dynamik der Getriebe] (translated from Russian), Berlin, Verlag Technik, 1952, 276 figs., 421 pp. DM 22.

This textbook for the academically educated engineer is excellent for acquainting students of metallurgical and mining departments with mechanisms. It is a comprehensive work but, owing to the variety of subjects dealt with, many problems are only described by way of example, and reference is made to other Russian works dealing with the particular problem in more detail. As a composite, showing the interrelationships between the different sciences and aspects to form a useful mechanism and, in the end, a useful machine, the book can be considered as well planned and certainly reaching its objective.

In kinematical respect, the problems of geometrical synthesis are not dealt with; also modern (in particular German) work on cam design has not been considered. Wide use is made of geometrical construction, in particular, velocities and accelerations, and thus the mathematics involved is very limited, in contrast to Tschebyschev's theorems. For instance, planetary gears are treated by three methods: (1) Table method (known as Swamp's rule); (2) analytical methods (Goodeves' formula); (3) graphical method (introduced by K. Kutzbach, but ascribed to L. P. Smirnow). The relation between the number of joints and members for positive mechanisms with one degree of freedom is ascribed to P. L. Tschebyschev (in the first formula (p. 46) a printing error occurs). Many theorems which the reader relates to certain persons or schools will appear in this book connected

with another name, in most cases a Russian one. It would be too involved to raise here the question of priorities, and a possible explanation might be that the Russian author or professor had to refer to a previous treatment in another Russian source for convenience, if for no other reason. While this may hold in several instances, it is felt that the historical treatment of kinematics is, in this book at least, not fair and in particular does not do justice to the German schools of Reuleaux, Burmeister, and Grashof, not to mention the many successors up to the most recent times.

The historical section starts with Aristotle, to whom the primitive mechanisms are ascribed, and mentions only Agricola (16th century) and Leupold (18th century) as more modern authors. All non-Russian work is described in one sentence: "About the end of the 18th century the French and English schools of the machine theory were originated," without giving names and quoting details. This is followed by a description of the Russian development starting with Tschebyschew (the work of whom certainly is not honored in this book) and ending with reference to the publications of 16 Russian authors: "These Russian works take the first place in international sciences." It would be wrong to assume that non-Russian authors are not mentioned. The basic knowledge on dynamics is ascribed to one J. Newton, "Mathematical principles of natural philosophy," 1915-1916, whom some readers may identify as Sir Isaac Newton, 1642-1727; with reference to friction, it is credited to Coulomb and the given analysis of cams is ascribed to F. Fuhrmann (read Furman), New York, 1921. There is also some criticism of non-Russian authors; with regard to the classification of mechanisms it is said: "Those suggested by Reuleaux, Lynen, and others must be considered as less useful." As a matter of fact, the book follows more or less the six groups of mechanisms given by F. Reuleaux, and appears to accept a number of his ideas, in particular on gears [hyperbolic and toroidal (globoid) shapes]. The method of M. Lynen found only representation in recent volumes of "Die Huette" (however, his notion "Zweischlag" (two-lever connection) is used in several instances).

The book concludes with a bibliography of 28 Russian textbooks on kinetics and kinematics of machines published between 1916 and 1946, representing the most comprehensive list of this Russian literature the reviewer has hitherto seen. No foreign author was found eligible for inclusion in this list.

P. Grodzinski, England

333. Altman, F. G., Spatial linkages of six elements (in German), *ZVDI* 96, 8, 245-249, Mar. 1954.

This well-illustrated paper includes a development and tabulation of six-membered mechanisms in which each member is joined to two or more others by hinges or socket joints. The number of degrees of freedom is considered for each mechanism. Applications as drive connections between shafts are discussed and shown. In particular, photographs of eight of those singular linkages employing only six hinged joints are discussed briefly. It is remarked that the discovery of useful applications of these mechanisms is a good problem for machine designers.

M. Goldberg, USA

334. Hain, K., Springs in oscillating linkages (in German), *ZVDI* 96, 8, 250-254, Mar. 1954.

The force of a spring may be applied on the end of a metal band which is wrapped over a cam. Graphical methods are given for determining the shape of the cam to give a constant moment to take play out of a mechanism and yet not cause undesired motion. In other applications, springs are used for obtaining desired variable moments, as in driving past dead-center positions.

M. Goldberg, USA

335. Förster, H. J., Föttinger transmissions in power branching-offs (in German), *VDI-Forschungsheft (B)* 20, 444, 44 pp., 1954.

Improvements of efficiency are studied which can be expected by combining a Föttinger hydraulic transmission with a mechanical differential. Equations which were established for the calculation of such systems become rather simple when introducing a characteristic transmission factor as the speed ratio of the driven and the driving side of converter at fixed speed of input or output. Among the large variety of possible combinations there are two outstanding types of such systems with two branching-offs; i.e., where the planetary gear either unites or divides the power. Assuming a specific practical and, later on, a more general simplified characteristic of the Föttinger transmission, these two types are investigated in great detail by varying all the design quantities and by discussing their influence on the manner of operation and on the efficiency of the system.

From author's summary by A. S. Hall, USA

336. Stott, T. C., Problems in the design and development of an economical automobile gear-box, *Instn. mech. Engrs. Auto. Div. Proc.* no. 1, 11-28, 1953-1954.

337. Mihailovic, D., On a general method for reducing the problem of two bodies with variable masses to the two-body problem in celestial mechanics (in Serbo-Croatian, with Italian summary), *Bull. Soc. Math. Phys. Serbie* 5, 1/2, 67-76, 1953.

Author generalizes the method of Batyrev [*Akad. Nauk SSSR Astr. Zhurnal* 26, 56-59, 1949] for reducing the problem of two bodies with variable masses to the classical two-body problem in celestial mechanics.

Using two theorems of Duboshin [*ibid.*, 9, 53-56, 1932] and the fact that the total mass $M = m_1 + m_2 = f(t) \rightarrow 0$ as $t \rightarrow \infty$, author concludes that the orbit is neither periodic nor asymptotic in the finite region of motion; moreover, it is impossible to find initial conditions for which the trajectory approaches an ellipse as its limiting orbit.

The qualitative analysis of Batyrev concerning the shape of the trajectories is confirmed.

E. Leimanis, Canada

338. Sretenskii, L. N., The motion of three particles on rotating orbits (in Russian), *Vestnik Moskov. Univ. Ser. Fiz.-Mat. Estest. Nauk* 8, 15-19, 1953.

Newton ["Principia," Book I, Sect. IX] proposes to find a central force such that under its action a particle moves in a curve which revolves about the center of force in the same manner as another particle in the same curve at rest. A geometrical analysis showed that the required central force differs from the inverse square law by a force varying as the inverse cube of the distance.

The author shows that by addition of such a force to the force of Newtonian attraction, three particles may be made to describe in a plane revolving about their common center of gravity the same orbits as Lagrange's equidistant particles would describe in the fixed plane under the action of Newtonian attraction alone.

E. Leimanis, Canada

339. Kil'chevskii, N. A., Functions of stress, velocity, and density in static and dynamic problems in the mechanics of continuous media (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* 92, 5, 895-898, Oct. 1953.

Author gives a different method to that of Arzhanikh [see *AMR* 5, Rev. 3129] for introduction of generalized stress functions in static and dynamic problems of continuous media. The starting point is a tensor in a space of four dimensions whose components contain six components of the three-dimensional

stress tensor, three components of the velocity vector, and the density of the medium. Accordingly, the number of generalized stress functions introduced by author is ten, while Arzhantikh, having superfluous functions, operates with twenty-one functions. In particular cases the number of these new stress functions can be made less than ten.

E. Leimanis, Canada

340. Barenblatt, G. I., Propagation of instantaneous perturbations in a medium with nonlinear relation of stresses to strains (in Russian), *Prikl. Mat. Mekh.* 17, 4, 455-460, July-Aug. 1953.

Paper gives a statement and examination of a new problem in the dynamics of a solid medium deviating from Hooke's law, due to K. A. Rokhmatulin [*Uchen. Zap. Mosk. Gos. Univ.* 1951; title source, 9, 1, 1945]. The author studies the propagation of a wave in an unbounded medium, the medium satisfying an arbitrary relation between the stress and deformation (in general, nonlinear). The problem is studied with the aid of a dimensional method applied by L. I. Sedov [*Gosud. Tekh. Teor.*, 1951] for the construction of an exact solution of a different problem in the mechanics of a solid medium. The stress σ is related to the deformation ϵ by the formula, $\sigma = \rho_0 v^2 \phi(\epsilon)$, where ρ_0 is the density of the undeformed medium, v a certain constant. The function $\phi(\epsilon)$ is arbitrary.

The differential equation governing the disturbance $u(x, t)$ is known to be [Ilyushin, A. A., "Plasticity," *Gosud. Tekh. Teor.*, 1948] $u_{tt} = v^2 \phi'(u_x) u_{xx}$, and the boundary conditions are $u(x, 0) = 0$, $u_t(x, 0) = 0$, $u_x(0, t) = \alpha$, α a given constant and taken to be positive. The form of $u(x, t)$ as given by Sedov, is $u = -vtf(x/vt)$, where f is a certain function. The equation satisfied by f is obtained by putting the above expression for u into the partial differential equation for $u(x, t)$; thereby leading to an ordinary differential equation for $f(\xi)$, with $\xi = x/vt$. The form of the solutions for $u(x, t)$ for certain practical cases of interest are listed. For example, if $\phi(\epsilon) = \epsilon + \beta\epsilon^2$, $\beta > 0$, then $u(x, t) = \alpha(1 + \alpha\beta)^{1/2}t - \alpha x$, for $0 \leq x \leq x_0 = (1 + \alpha\beta)^{1/2}t$, and $u(x, t) = 0$, for $x \geq x_0$.

Other results are likewise listed, the details of the method and other considerations being too lengthy to list here.

J. J. Brandstatter, USA

341. Rabinowicz, E., Rightmire, B. G., Tedholm, C. E., and Williams, R. E., The statistical nature of friction, First Ann. ASME-ASLE Conf., Baltimore, Md., Oct. 1954. Pap. 54-LUB-2, 7 pp.

Sliding experiments have been carried out using copper surfaces in solid contact, and the friction traces have been analyzed statistically to study the spontaneous fluctuations in the friction force. The results suggest that the calculation of the standard deviation of the values of the instantaneous friction force can yield much information about the nature of the sliding process. High loads and smooth-surface finish produce very steady traces for well-lubricated surfaces, while for unlubricated surfaces a rougher finish is required.

From authors' summary

Servomechanisms, Governors, Gyroscopics

342. Schönfeld, H., Automatic control. Selected topics [Regelungstechnik. Ausgewählte Kapitel], (Schriftenreihe des Verlages Technik, Bd. 92), Berlin, Verlag Technik, 1953, 84 pp., 39 figs. DM 7.20.

The major objective of this brochure is to provide an introduction to servomechanism analysis for young engineers. No original methods are used in the text, but the treatment of the topics covered is clear and actually at an intermediate level.

Chap. I describes the basic equations of the regulating systems and the stability criteria (Hurwitz, Cremer-Leonhard, Routh, Strecker-Nyquist-Ludwig). Chap. 2 deals with general theoretical foundations, such as transient and transfer-function analysis, the Laplace transform, Carson's formula, Duhamel's integral, and integral equations.

Chap. 3 is devoted to the analysis of the row regulator by aid of its amplitude-phase characteristics. This chapter is a German translation of Solodovnikov's lectures in the seminary of Telemechanik Institute (January 1948), published in *Nach. Akad. Wiss. der UdSSR, Abt. Tech. Wiss.*, 1949, no. 4, p. 473.

At the end of each chapter are included a summary and short bibliography, mainly in German and Russian. A few examples illustrate the paper. One drawback to the work is that the print is in very small type.

D. Rašković, Yugoslavia

343. Westcott, J. H., Synthesis of optimum feedback systems satisfying a power limitation, *Trans. ASME* 76, 8, 1253-1259, Nov. 1954.

Paper describes two methods of synthesizing feedback systems in which stability considerations are qualified by an overriding limit on power demand. The three basic requirements for either method are: (a) a spectral density function of input signals; (b) a transfer function of fixed elements (i.e., basic elements essential for the performance of the task); and (c) the maximum rating of the power source. Examples are given. In one method the form of the stabilizing means has to be specified. The criterion, that the mean square error be a minimum subject to the power limitation, is applied. This gives as a result the optimum design parameters of the specified stabilizing means. The other method, based upon the same criterion, uses a variational principle. A solution by this method gives a stabilizing means for the system which, within the specified power limit, cannot be improved. One example of this method illustrates the desirability of allowing a finite time delay between the input and the output of a feedback system.

From author's summary

344. Janssen, J. M. L., Control-system behavior expressed as a deviation ratio, *Trans. ASME* 76, 8, 1303-1309, Nov. 1954.

In order to bridge the gap between process-control practice and modern control theory, an attempt is made to reduce this theory to its bare essentials. A simple picture is drawn of what control does and how it does it, use being made of the familiar concepts of resonance and damping. Thus a theoretical background is provided for common-sense judgments on control quality and controller settings. The picture given is applicable to both feedback and feedforward control.

From author's summary

345. Davis, S. A., Mechanical components for automatic control, *Prod. Engng.* 25, 9, 169-200, Sept. 1954.

Presented are the factors involved in the design and application of gear trains, the operating characteristics and application techniques of various types of clutches, and a discussion of typical commercially available mechanical elements.

From author's summary

346. Ulanov, G. M., Automatic regulation and following systems working through an open and closed loop and the invariance principle (in Russian), *Doklady Akad. Nauk SSSR (N. S.)* 96, 5, 979-981, 1954. (English translation by M. D. Friedman on file with Scientific Translations Division, Library of Congress.)

(a) Reduction of errors in control systems by addition of ex-

ternal control paths. (b) Feed-forward loop is added to standard control system, modifying input such that the error is identically zero without altering loop stability.

Reviewer feels that the contribution is not significant since practical application is almost impossible. L. A. Gould, USA

Vibrations, Balancing

(See also Rev. 334)

347. Kharkevich, A. A., Sustained (self-excited) vibrations [Avtokolebaniya], Moscow, State Publ. Techno-Scient. Lit., 1953, 170 pp. \$0.40.

Author defines "autovibrating systems" as a circuit capable of maintaining sustained vibrations and consisting of a source of energy, a control valve, and a feedback from oscillating "body" to valve. The treatment is nonmathematical; numerous schemes and characteristics serve to give a clear presentation of the main parameters and stress the similarity of the circuits. Book considers energy distribution, work diagrams, steady and unsteady vibrations, reciprocating engines, pneumatic hammers, etc., friction pendulum, machine-tool cutter vibrations, reeds, clocks, electric-circuit phase analysis, relaxation vibrations, friction-induced vibrations, vibrations in hydraulic systems, vibrations in bimetal strips, vibration in pipes, galloping wires, flutter, shimmy, pendulum and high-frequency (electronic) oscillators. Appendixes provide mathematical interpretation of Lissajous figures, shimmy, regulator vibrations, and R. C. oscillators.

The all-Russian (with one exception—Rayleigh's "Theory of sound") bibliography has 24 items.

The reviewer considers that the author has succeeded in producing a lucid and stimulating introduction to the subjects.

J. L. Koffman, England

348. Bishop, R. E. D., On the graphical solution of transient vibration problems, *Instn. mech. Engrs. Proc.* 168, 10, 299-322, 1954.

Paper is a general treatment with many examples of the "phase-plane" method of treating vibration problems, i.e., the method whereby displacement is plotted against velocity in a diagram. The use of this method for nonlinear problems is well known. The author applies it to transient and forced vibrations, to the deflections of columns with end loads as well as lateral loads, and to bending-moment distributions in beams. The discussions by others and the rebuttal by the author are a valuable extension of the paper.

J. P. Den Hartog, USA

349. Reissner, E., Note on the problem of vibrations of slightly curved bars, *J. appl. Mech.* 21, 2, p. 195, June 1954.

An approximate analysis of the effect of curvature of a slightly curved bar on its frequencies of vibration is presented. Under the assumptions that the center line of the bar is a plane curve and the vibrations take place in this plane, that the square of the slope is small compared with unity, that the ends of the bar are immovable, that the effect of longitudinal inertia is negligible compared with the effect of transverse inertia, the following integro-differential equation is derived

$$(Dw)'' - [w_0'' - L \int^L (1/c) dx] - L \int^L w_0' w' \alpha x + \rho w'' = q$$

where w_0 represents the undeformed center line of the beam, w its displacement, $D = EI$, $C = EA$ its characteristics (E is Young's modulus, I moment of inertia, and A area of cross section), $2L$ its total length, ρ its mass density.

The above equation is applied to the study of free vibrations of simply supported beams of uniform cross sections in the two

following cases: (a) center-line equation: $w_0 = H \cos \alpha x$, ($\alpha = \pi/2L$); (b) initial curvature equation

$$w_0'' = \sum_{n=0}^{\infty} A_n \cos \alpha_{2n+1} x + B_n \cos \alpha_{2n} x; (d_n = n\pi/2L)$$

The effect of longitudinal inertia is discussed and it is shown that for shallow arches it is negligible.

In reviewer's opinion this paper constitutes a very valuable contribution to the problem of vibrations of curved bars.

E. Volterra, USA

350. Grodtko, L. N., Forced vibrations of a rod in bending with linear damping at a restrained support (in Russian), *Prikl. Mat. Mekh.* 17, 3, 607-610, Sept./Oct. 1953.

Author considers a cantilever beam or rod with an arbitrary forcing function acting along it. One end is free and the other is built-in in such a way that there is damping proportional to the angular displacement. The solution is developed in terms of the eigenfunctions of the beam free from damping. The general solution is obtained and the limiting cases, when the coefficient of damping approaches zero or infinity, are discussed.

E. Saibel, USA

351. Oberst, H., Becker, G. W., and Frankenfeld, K., Damping the vibrations of thin sheet metal (in German), *Akust. Beihefte* 4, 1, 433-444, 1954.

Since the appearance of part I [title source, 2, 4, AB, 181, 1952] progress has been made in the development of materials having high internal energy losses, which are used for damping the vibrations of thin sheet metal. The technique for measuring the dynamical properties of those materials has been completed. The advances made are described in the present paper. The possibility of comparing different damping substances is discussed. It is shown how a maximum of damping efficiency in the desired ranges of frequency and temperature can systematically be obtained in the case of plasticized high polymers mixed with appropriate inorganic filling materials. Finally, problems of the practical applications of the damping mixtures are discussed.

From authors' summary

Wave Motion, Impact

(See also Rev. 340)

352. Protter, M. H., New boundary value problems for the wave equation and equations of mixed type, *J. rational Mech. Analysis* 3, 4, 435-446, 1954.

Author generalizes Goursat's problem for hyperbolic equations in two independent variables, in which values of unknown function are prescribed along two intersecting curves so as to determine solution in "influence domain." He obtains formulation of, and proof for, uniqueness of solution for Goursat's problem for three-dimensional wave equation, investigating various cases; e.g., when solution is prescribed on a boundary consisting in part of a characteristic cone.

Generalizations of Tricomi's problems for equations of mixed elliptic-hyperbolic type are also considered. F. T. Adler, USA

353. Karbowiak, A. E., The elliptic surface wave, *Brit. J. appl. Phys.* 5, 9, 328-335, Sept. 1954.

Author discusses an elliptic wave guide, obtaining the solution in terms of Mathieu functions. He shows that though the field is exponentially small at large radial distances from the axis of the guide, the solution is not asymptotically the same as that of a circular guide. The solution for the elliptic guide passes over

continuously into that for a circular guide as the eccentricity vanishes. Author has made an analysis of a circular guide deformed into an ellipse of small eccentricity and has also considered the effect of corrugations. He states that a difference of up to 10% from the circular form is possible without significant effect on the results for a circular guide. J. M. Jackson, Scotland

354. Hines, C. O., Reflection of waves from varying media, *Quart. appl. Math.* 11, 1, 9-31, Apr. 1953.

Formulas are found for the coefficient of reflection from varying media of a type encountered in physics. These are applied approximately for some general classes of media, and exactly for some specific cases. Many media which would normally be expected to be highly reflecting are shown to be completely transparent to certain waves at least and, in some cases, to a whole spectrum of waves. The results are considered both for electromagnetic (or other classical) waves and for mass waves.

From author's summary

355. Maue, A.-W., The wave of unloading caused by a sudden cut in an elastic body (in German), *ZAMM* 34, 1/2, 1-12, Jan./Feb. 1954.

In the problem discussed in this paper, an infinite elastic medium is initially under a uniform tension parallel to Oy : at time $t = 0$, the body is cut instantaneously along the half plane $y = 0, x < 0$. Elastic waves of unloading are initiated and the paper evaluates the stresses set up in the body by these waves. The problem is treated as two-dimensional in the xy -plane and it may be regarded as an idealization of the phenomena accompanying the formation of a crack in a solid. The solution leads to an integral equation which is similar to one previously treated by the author [AMR 7, Rev. 726]. The stress distribution in the immediate vicinity of the crack is considered in greater detail and compared with the author's previous result [AMR 6, Rev. 777].

R. M. Davies, Wales

356. Das Gupta, S. C., Waves and stresses produced in an elastic medium due to impulsive radial forces and twist on the surface of a spherical cavity, *Geofis. pura appl. Milano* 27, 3-8, 1954.

Expressions are derived for the displacements and stresses produced when an impulsive radial pressure or an impulsive couple is applied to the free surface of a spherical cavity in an ideal elastic medium of infinite extent. The applied impulses are assumed to be Dirac δ -functions and, in the case of the radial pressure, the outward flow of energy is calculated.

The solution of the problem for an impulsive radial pressure was given by Japanese workers in 1935 and 1936 and, more recently, it has been discussed by J. A. Sharpe [*Geophysics* 7, 144, 1942].

R. M. Davies, Wales

357. Bishop, R. E. D., The phase-plane construction in problems of elastic impact, *Engineer, Lond.* 196, 5089, 168-170, Aug. 1953.

Author considers a prismatic bar of arbitrary length loaded at one end of an axial force, which is a known function of time. Other end is free. Particle displacements are calculated in two ways: well-known wave solution and normal mode solution [see Timoshenko, "Vibration problems in engineering," p. 314]. Differential equation in the latter approach is solved graphically by means of phase-plane constructions.

M. Kuipers, Holland

358. Crede, C. E., The role of shock-testing machines in design, *Mech. Engng., N. Y.* 76, 7, 564-567, July 1954.

359. Inui, T., Japanese developments on the theory of wave-making and wave resistance, *European Shipbldg.* 4, 3, 93-99, 1954.

In this report, author attempts to give a general view of the developments in the theory of wave making and wave resistance during the past ten years (1944-1953) in Japan. Reference is made to more than seventy papers. From author's summary

360. Crewe, P. R., A proposed theory to cover water impacts of seaplanes in which the craft has constant attitude and a tangential-to-keel velocity relative to the water, *Aero. Res. Coun. Lond. Rep. Mem.* 2513, 54 pp., Dec. 1946, published 1954.

361. Blokh, E. L., Horizontal hydrodynamic impact of a sphere, in the presence of a free liquid surface (in Russian), *Prikl. Mat. Mekh.* 17, 3, 579-592, Sept./Oct. 1953.

Three cases for hydrodynamic impact are considered: (1) A sphere floating on the surface of an ideal liquid (referred to as the exterior problem by the author). (2) A spherical membrane filled with a liquid having a free surface (referred to as the interior problem by the author). (3) A sphere floating on the surface of an ideal liquid contained in a spherical vessel whose surface is concentric with that of the floating sphere (referred to as the mixed problem by the author).

The problems are basically attacked by relating the velocity potential of the disturbed liquid after the application of an impulse to the impulse itself by: $p_i = -\rho\varphi$ where $\varphi(x, y, z) =$ velocity potential of the motion of the liquid, $p_i =$ impulse pressure and specifying that φ satisfies Laplace's equation. The velocity φ is then placed in the form

$$\varphi = \sum_{n=1}^{\infty} \sum_{m=0}^{n-1} (A_n^m \cos m\omega + B_n^m \sin m\omega) r^n P_n^m(\mu)$$

where $P_n^m(\mu) =$ the associated Legendre function of the first order and $\mu = \cos \theta$. Spherical coordinates r, θ, ω are used throughout the analyses and calculations.

All three problems are solved by evaluating the velocity potential as a uniformly and absolutely convergent series in the interval $-1 \leq \mu \leq 1$ by using inequalities based on Stirling's formula for $n!$ and the integral representation of a Legendre function. An approximate solution is suggested by the author, which utilizes an analyzable elliptic integral of the second kind in conjunction with a series of Legendre polynomials. The approximation obtained for the first case is correct to within 0.37% of the accurate solution.

N. M. Matusewicz, USA

Elasticity Theory

(See also Revs. 357, 379, 383, 384, 415, 426, 487)

362. Rivlin, R. S., and Topaloglu, C., A theorem in the theory of finite elastic deformations, *J. rational Mech. Analysis* 3, 5, 581-589, Sept. 1954.

Authors extend the procedure of solution of problems in second-order elasticity theory, described in a previously published paper by R. S. Rivlin, to the solution of equations of third- and higher-order theory of elasticity for finite elastic deformations.

W. Ornstein, USA

363. Taleb, N. J., Method of computing principal strains, *J. appl. Mech.* 21, 2, 197-198, June 1954.

Author presents a concise method for finding the principal strains of a two-dimensional strain distribution when the linear strains along three arbitrary directions are known. The results

can be used for the solution of problems of strain rosettes with angles different from those in the usual types. Reviewer remarks that, in view of the existing mathematical analogy between stress and strain distributions, the analytical approach of the author can be applied also to two-dimensional stress distributions.

G. A. Zizicas, USA

364. Solvey, J., Some notes on the torsion-bending constant, *J. roy. aero. Soc.* 58, 521, 367-371, May 1954.

The torsion-bending constant of open sections is of great importance in the calculation of buckling loads under compression of struts failing in the torsional or torsional-flexural mode. It involves computation of the warping of the cross section, and misunderstandings arising out of terminology and notation often mislead the users of the formulas. This note clarifies the terminology without going into proofs, as well as presenting the equations required, using a consistent notation.

From author's summary

365. Ōkubo, H., The torsion and stretching of spiral rods. *II, Quart. appl. Math.* 11, 4, 488-495, Jan. 1954.

State of stress in spiral rods (coiled springs) is solved as a problem in three-dimensional elasticity. The analysis is limited to small values of the helix angle. Numerical results for the rod of circular cross section are presented. J. E. Duberg, USA

366. Reiner, M., Second effects in elasticity and hydrodynamics, *Bull. Res. Council Israel* 3, 4, 372-379, Mar. 1954.

Paper discusses the second-order effects appearing as interactions between the isotropic and the deviatoric components of the stress and the strain, or rate of strain, tensors for the elastic solid and the viscous fluid. It is shown that in the linear elastic solid such effects arise for large strains and depend on the particular form of the definition of such strain. In viscous liquids in which the deformation reached is of no significance, second-order effects can only arise from a nonlinear term in the viscosity equation and are, therefore, restricted to particular nonlinear viscous fluids known as "Reiner" fluids. The discussion is illustrated by the analysis of elastic torsion and viscous torsional flow.

A. M. Freudenthal, USA

Experimental Stress Analysis

(See also Revs. 363, 415, 507)

367. Hilscher, R., Grading of photoelastic model materials (in German), *Forsch. Geb. Ing.-Wes. (B)* 20, 3, 66-76, 1954.

Author discusses the information which may be derived from a specimen in pure bending and which would enable the investigator to assess the merits of different model materials. Such materials are characterized by the author by the use of four parameters: (1) The fringe order/cm thickness of the model for a strain of 10^{-3} ; (2) the departure from proportionality of the stress-optical effect; (3) speed of "optical creep" at an arbitrary stress level of 120 kg/cm²; (4) sensitivity to time-edge effect expressed as fringe order/cm thickness per day.

A table giving numerical values of these quantities for 15 model materials is included in the paper. E. K. Frankl, England

368. Attia, Y. G., Fitzgeorge, D., and Pope, J. A., An experimental investigation of residual stresses in hollow cylinders due to the creep produced by thermal stresses, *J. Mech. Phys. Solids* 2, 4, 238-258, June 1954.

Series of short, thick-walled case iron cylinders were subjected to a radial flow of heat by heating the bore and cooling the outer

diameter. Radial temperature gradients and time at temperature were varied. Residual tangential stresses were determined by a modification of Davidenkov's method. Application of the results to the study of failures of combustion-chamber components is discussed in detail.

Paper includes discussions of the principles of thermal stress analysis and stress relaxation; the test apparatus, procedure, program, and results; and the possible significance of results to other configurations. A detailed derivation of the methods used for residual stress determination is given in the appendixes.

W. E. Cooper, USA

369. Thorsen, W. J., A multiple-unit stress relaxometer, *Text. Res. J.* 24, 10, 899-902, Oct. 1954.

The application of an improved resistance-wire strain gage to a multiple-unit instrument for the measurement of stress relaxation in single fibers is described. Forces are autographically recorded with a precision and accuracy of better than 3 mg or 1/2% of full scale. The instrument is stable over long periods and is designed to record directly in units of stress, the scale being identical for all fibers.

From author's summary

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 335, 349, 350, 365, 387, 399, 401, 402, 413)

370. Emschermann, H.-H., and Rühl, K., Bending strain in beams caused by transverse impact of a mass (in German), *VDI-Forschungsheft (B)* 20, 443, 32 pp., 1954.

Authors provide an extensive study of the problem of the flexure beam subjected to transverse impact of a moving load. The paper is divided into essentially three parts. These parts are concerned with experimental setup and resistance-wire strain-gage measurements on metal beams, photoelastic methods and tests, as well as practical methods for the calculation of strains. Good photoelastic pictures and excellent strain oscillograms are shown. The paper ends with a bibliography of forty-seven technical papers, containing six by the reviewer. Results given in the papers by the reviewer are discussed and analyzed at length. Agreements in certain details of experimentally determined strains are gratifying. The phenomena of initial maximum strain and approximate independence of length of beam for that strain, first noted by the reviewer [*Proc. Soc. exper. Stress Anal.* X, no. I, 157-164, 1953], are verified and discussed.

W. H. Hoppmann, II, USA

371. Uzdalev, A. I., Bending stresses of anisotropic two-layered cylinders by transverse forces (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* 15, 35-42, 1953.

A problem of an isotropic two-layered cylinder has been solved by N. I. Muskhelishvili, 1949; and a solution for a simple anisotropic case was obtained by S. G. Lekhnitzki, 1950. In this paper, a problem of a hollow cylinder, consisting of two elastically different concentric layers, is solved for small deformations, under assumption that the layers are bounded rigidly one to another.

The method of the solution consists of expressing stresses as a combination of powers of r and trigonometric functions of θ ; r, θ are polar coordinates.

The following conclusions have been reached: (1) If $a'_{13} \geq a'_{14}$, where $a'_{ij}, j = 1, 2$ are elastic constants of the external and internal layers, respectively, then the stresses are finite, otherwise they increase indefinitely in the neighborhood of the axis of the cylinder; (2) if $a'_{33} = a'_{34}$, then the normal stresses are continuous, otherwise they exhibit discontinuity on the surface of contact.

A few numerical examples for the specific values of the elastic constants illustrate the results.

R. M. Evan-Iwanowski, USA

372. Horne, M. R., The elastic-plastic theory of containers and liners for extrusion presses, *Inst. Mech. Engrs.*, 12 pp., 1954.

Paper contains a comprehensive account of theoretical aspects concerning the design of containers and liners for extrusion presses. Author reviews elastic-plastic theories and gives reasons for selecting a statically determinate analysis for plane stress based on Tresca's yield criterion (strain-hardening ignored). This solution is applied to containers both with and without liners. Combinations of three possible zones in container and/or liner are considered. Zones are defined by whether the material is elastic, plastic under the action of circumferential and radial stresses giving the maximum stress difference, and plastic by virtue of the axial and radial stresses giving the maximum stress difference. Theory is worked out in detail and expressions derived for internal pressures sufficient to cause initial yield, full plasticity, and the occurrence of alternating yield on the inner surface of either the liner or container. Consideration is also given to the progressive penetration of a taper liner against the taper at pressures less than those required to produce full plasticity. Results are presented in the form of charts which cover a wide range of practical conditions.

Reviewer remarks that this paper treats an engineering problem in a scholarly yet practical manner. It is a noteworthy example, where rigor in analysis is subordinated in a satisfactory manner to the more practical issues associated with an important design problem.

M. C. Steele, USA

373. Pivovarov, A. M., Determination of tangential stresses in torsion of prismatic shafts and of shearing forces in bending of simply supported plates (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* 15, 61-72, 1953.

A numerical method, developed by M. G. Slobodyanskii, 1951, has been employed to determine (1) tangential stresses in torsion of shafts whose cross-sectional areas consist of rectangles, triangles, trapezoids or a combination of these figures; (2) shearing stresses in bending of a simply supported rectangular plate.

The method is very effective and, with comparatively small amount of effort, the obtained results agree well with the values derived from the known exact solutions.

R. M. Evan-Iwanowski, USA

374. Kutz, W., A gearing chart (in German), *Maschinenbau-Technik* 2, 10, 460-462, Oct. 1953.

Paper summarizes well-known interrelations of undercutting, contact ratio, tooth pressure, velocity of sliding, manufacturing methods, and compactness of drive for gears. A design chart is presented which permits quick determination of the allowable minimum number of teeth and resulting contact ratio for given gear ratios, pressure angles, and addendum factors. Two numerical examples and the underlying analytical formulas are included.

G. A. Nothman, USA

375. Hiersig, H. M., On the overload capacity of gearings (in German), *ZVDI* 96, 8, 221-225, Mar. 1954.

During postwar years great progress has been made in gear research, and reliable methods exist for the computation of the strength of tooth-roots and tooth-flanks under given load. Present paper deals with the question of determining the load for which a gearing has to be computed, since under working conditions the nominal load is usually exceeded. Author emphasizes

the importance of measurements and quotes empirical load factors for flexible couplings and gearings, the latter according to AGMA standards. The paper should prove useful to designers.

P. Kohn, Czechoslovakia

376. Boerner, E. H., Constant force compression springs, *Prod. Engng.* 25, 9, 129-135, Sept. 1954.

Plates, Disks, Shells Membranes

(See also Revs. 368, 395, 407)

377. Joga Rao, C. V., and Rattayya, J. V., A note on partially fixed long rectangular plates under uniformly distributed loads, *J. Indian Inst. Sci. (B)* 36, 2, 43-47, Apr. 1954.

Paper deals with extremely long thin plate with partially clamped edges under equally distributed load. Difference between are along deflection curve and its cord and tensile force thus produced are taken into account. For a given maximum stress, a diagram shows allowable load as dependent on edge fixity coefficient and width-to-thickness ratio.

H. Craemer, Germany-Pakistan

378. Müller, W., Bending theory of a rectangular plate supported by several (k^2) thin columns (in German), *Öst.-Ing. Arch.* 8, 1, 1-10, Feb. 1954.

Author presents an analysis of uniformly loaded rectangular plates supported on several (k^2) thin columns symmetrically arranged about the center lines of the plate. Boundary conditions are equivalent to zero slope and zero shear (but not zero deflection) around the edges of the plate, i.e., for a plate $a + b$ with the origin at one corner, $\partial w / \partial x = 0$ and $V_x = 0$ at $x = 0$, $x = a$, etc. The supports are first regarded as small rectangles with uniform upward pressure q and the total loading is expressed as $p(x, y) = p_0 - q \cdot f(x)g(y)$, where $f(x)$ and $g(y)$ are Fourier series in cosine terms only.

The size of the supports is then reduced to zero and the deflection corresponding to the loading is deduced by using the plate equation. The deflection series also contains cosine terms only, to satisfy the boundary conditions.

By using known summations, author reduces the double Fourier series in the deflection to a single series.

Separate consideration is given to cases where k is an even number and where k is odd. The case of $k = 4$ (sixteen supports) is treated in some detail and, by arranging that the supports overlap in various ways, the cases of 8, 4, and 1 support are deduced. Confirmation of results previously published by the author for 4 supports and 1 support is obtained.

Deduction of the bending moments from the deflection is also included.

A. Burn, Australia

379. Karunes, B., A rigid curvilinear polygonal core in an infinite plate under tensions at infinity and shear, *Indian J. Phys.* 28, 3, 133-140, Mar. 1954.

Author considers the problem in title for the cases of all-around tension at infinity, uniform tension at infinity at an inclination to the x -axis, and a uniform shear in the plane at infinity.

The method used is that of Muskhelishvili. Author makes incorrect statement by asserting that the method discards the stress function and replaces it by two functions of a complex variable.

The more general problem of the title has been treated by several Russian authors, notably by D. I. Šerman.

J. J. Brandstatter, USA

380. Frandsen, P. M., On plates and slabs (in Danish), *Byggestat. Medd.* no. 1, 1-20, 1953.

Paper gives a simplified method for determination of the moments and forces in slabs and plates which avoids the necessity of integrating the fourth-order differential equation giving the plate deflection in terms of the plate load. Use of the so-called scalar moment $U = (M_x + M_y)/(1 + \nu)$ shows some analogies between plates and beams. Further introduction of the vector moments $V_{xy} = (M_x - M_y)/(1 - \nu)$ and $W_{xy} = 2M_{xy}/(1 - \nu)$ shows how the moments M_x , M_y , and M_{xy} and the shear forces may be determined from second-order differential equations. The application of this force method is illustrated by examples, dealing with statically determinate as well as indeterminate plates.

T. A. Mortensen, USA

381. Pfkhtunov, M. T., Variation method for the solution of problems in plane elasticity theory for a single-connected area bounded by two arbitrary curved and two parallel straight lines (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* 15, 43-60, 1953.

382. Kokje, J. K. J., A method for calculating prismatic and continuous shells by the Cross method (in Dutch), *Ingenieur* 66, 10, Bt.13-Bt.22, Mar. 1954.

Application of the Cross method to roof constructions (known as "Faltwerke" or "Flächentragwerke" in German, and "Vouw-schalen" in Dutch) consisting of thin flat plates intersecting in lines parallel to the longitudinal direction of the roof. A numerical example is given which permits comparison with results to be found in the German book on Flächentragwerke by Girkmann. Attention is given to stress distributions due to variation of temperature and shrinkage. Continuously bent shells are approximated by a finite number of slightly curved plates, which take the place of the flat plates in the previous calculations.

C. B. Biezeno, Holland

383. Galletly, G. D., Analysis of discontinuity stresses adjacent to a central circular opening in a hemispherical shell, *David W. Taylor Mod. Basin Rep.* 870, 30 pp., Jan. 1954.

The problem of determining the stresses and deflections at the juncture of pressure vessels formed by thin shells of revolution is simplified by the use of edge coefficients for various sections. Edge coefficients are known for some common types of thin shells such as cylinders. The edge coefficients for the circular hole formed by the intersection of a plane and a hemisphere are not known.

The article reviewed is concerned with the selection of a method that will give reasonably accurate edge coefficients with a minimum of labor for the case of the small crown opening in the hemispherical shell.

Edge coefficients for a particular case in which the ratio of radius/thickness was 90.5 and the included angle of the hole was 21° were worked out by three different methods: The Geckler approximation; the Esslinger approximation; and the more exact method by Love.

The differential equations for the axisymmetrical bending of a thin hemispherical shell of constant thickness are expressed in terms of the variables Q and V , the transverse shear force and the angular rotation of a shell element, respectively. In the Geckler approximation, Q and V and their first derivatives are neglected as small in comparison to the second derivatives. The solution of the resulting fourth-order differential equation in Q is greatly simplified, the results being expressed as functions of e and trigonometric functions.

In the Esslinger analysis, $1/\phi$ is substituted for $\cot \phi$, ϕ being the angular distance of an element from the axis of the sphere.

The solution is in the form of Bessel functions of the first order.

In the more exact method of Love the solution is in the form of Legendre functions of the first and second kind. Of the three, the Geckler approximation is the simplest method; the Esslinger method, though somewhat more complicated, seems to be the most practical. For the case investigated, Esslinger's method gave answers closest to those obtained using Love's method, which was taken as the standard. The results from Esslinger's method were 3% off. Those from the Geckler approximation were 15% off.

Reviewer believes this to be an excellent paper of general interest and of considerable practical use. The work is easy to follow and may be used as a model for similar analyses.

E. G. Allen, USA

384. Ban, S., Deformation of hyperbolic-paraboloid shells (in German), *Publ. int. Assn. Bridge struct. Engng.* 13, 1-16, 1953.

Author first gives the relation between stress and strain which subsists in shell elements in the form of parallelograms. He then sets up the differential equation of displacements, which is that commonly applied to shells of translation of any form of section. For the hyperbolic-paraboloid shell the differential equation is soluble, and a few loading cases are investigated. In a particular case of intersecting shells, author indicates the sequence to be followed in erection in order to achieve a bending-free stress system.

From author's summary by H. F. Long, Argentina

385. Mikeladze, M. Sh., Elastic and plastic deformations in fast rotating disks of varying thickness (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* 15, 21-34, 1953.

Author considers cases of rotational symmetry and shows how differential equations for radial stress in a rotating disk of variable thickness, variable modulus of elasticity, and arbitrary thermal expansion may be transformed into an integral equation of the Volterra type. Also, the same is shown for a thin conical shell of variable thickness, rotating about its axes, the point of departure being the differential equation for the angular deflection of the middle surface due to A. D. Kovalenko [AMR 6, Rev. 1544]. Special cases of rotating disks, e.g., with step-by-step constant thickness, are treated with conventional methods of integration. Last section treats problem of partially plasticized rotating disk with a center hole, in the outer parts of which the preceding theory will hold. Stress distribution of inner parts is determined by equilibrium condition and a flow condition. Numerical treatment of disk with thickness decreasing exponentially with radius concludes the paper.

F. K. G. Odqvist, Sweden

Buckling Problems

(See also Revs. 364, 378, 420)

386. Drucker, D. C., and Onat, E. T., On the concept of stability of inelastic systems, *J. aero. Sci.* 21, 8, 543-548, 565, Aug. 1954.

The nature of the instabilities possible in systems with non-linear elastic elements is studied by means of two idealized models. Both static and dynamic tests are applied and the influence of the size of the initial disturbance is studied. The inadequacy of the classical approach is clearly demonstrated and the authors suggest that the determination of maximum loads achievable in the presence of representative initial irregularities or disturbances should replace the calculation of critical loads. Equivalence of the results obtained by static and dynamic investigations is also demonstrated.

W. S. Hemp, England

387. Reinitzhuber, F., Approximate formulas for the buckling of struts with linearly variable axial loading (in German), *Publ. int. Assn. Bridge struct. Engng.* **13**, 309-319, 1953.

Approximate formulas are proposed for the effective buckling length and the effective constant compressive load of columns with linearly variable axial loading and various boundary conditions. In the plastic range these formulas are more accurate than the existing ones. They are derived directly for the elastic range and, for the plastic range, are adapted to the author's theoretical work [AMR 5, Rev. 2590] which has been only partly published.

P. P. Bijlaard, USA

Joints and Joining Methods

(See also Revs. 411, 416)

388. Carter, J. W., McCalley, J. C., and Wyly, L. T., Comparative test of a structural joint connected with high-strength bolts and a structural joint connected with rivets and high-strength bolts, *Bull. Amer. Rly. Engng. Assn.* **56**, 517, 217-267, Sept.-Oct. 1954.

Test under static loads of two full-scale joints representing the connections of a floorbeam hanger to the upper chord gussets of a railway bridge is reported in this paper. One joint was connected by rivets except that high-strength bolts were used in the two lowest lines of holes in the gussets. The other joint was connected entirely by high-strength bolts. From authors' summary

389. Moehler, K., Experiments and experiences with timber joints and timber structures (in German; English summary), *Schweiz. Arch.* **20**, 7, 224-236, July 1954.

Static and repetitive (up to 700,000) loadings of nailed timber joints, built-up columns and beams, and nailed timber bridges as well as field observations of nailed-timber truss and plate-girder highway and railroad bridges, exposed to the weather, yielded information during the past fifteen years which permits the author to imply that nailed structures can provide satisfactory service under almost any conditions.

Test data are presented for nailed plate girders of 25 to 60-ft span, the load-carrying capacity of which was limited by tension failures of their tension flanges (near knots) or buckling of their compression flanges. Attention was given to careful predetermined distribution of the nails within the joints. Nails in double shear proved to be superior to nails in single shear. When nailing the two crosswise layers of the diagonal web boards, nails in double shear caused less splitting than anticipated for the same boards in parallel or perpendicular arrangement.

The influence of the arrangement of the individual sections of the composite assembly of nailed built-up I-shaped columns and beams on their effectiveness is described on the basis of experimental evidence which indicates that in no case the computed moment of inertia is reached for nailed I-shapes. Furthermore, nailed I-shapes with side flanges proved to be superior to nailed I-shapes with top and bottom flanges.

Difficulties in assembly and observed weaknesses and failures of glued-up joints for trussed structures resulted in emphasis on the improvement of nailed joints by increasing both their stiffness and load-carrying capacity. Promising steps in this direction are; (1) preboring of nail holes, (2) use of hard hardwood gusset plates and splices, (3) insertion of steel sheets between members of timber joints, (4) use of longitudinally fluted and helically threaded nails without or with claw-plate inserts between members, and (5) use of two-ended nails (double nails) provided with perpendicular steel disks halfway between nail points parallel with the contact areas of the members to be jointed.

A list of 20 references concludes this well-illustrated and documented paper which introduces the reader to the present status of nailed structures in Europe.

E. G. Stern, USA

390. Sulzberger, P. H., The effect of temperature on the strength of wood, plywood and glued joints, *Aero. Res. consult. Comm. Australia Rep.* ACA-46, 1-44, Dec. 1953.

Paper describes experimental investigations made to determine the effect of temperature on the strength of wood, plywood, and glued joints. The investigations deal with reversible changes in strength, elasticity, and the like, which may accompany variations in the temperature of the material.

Results show that all properties investigated are affected by temperature at some moisture content, in many instances to such an extent that serious error is introduced in mechanical testing and in design where this factor is not taken into account. Relations are given from which the effects of temperature on certain properties of a species can be estimated quantitatively with considerable confidence for a wide range of temperatures and moisture contents.

From author's summary

Structures

(See also Revs. 358, 382, 413, 440, 474, 509, 524, 526)

391. Széchy, Ch., Foundation engineering [Alapozás], 2 vols., Budapest, Közlekedési Kiadó, 1952, 260 pp.; 480 pp., 406 figs., 101 photos. Ft. 90.

Book is based on the most recent results of soil mechanics as well as on the practical experience of resident engineers. It is meant not only for the students of the University but also for the design and practicing engineer.

The first volume discusses soil as a construction material. First the origin, classification, deformation, and resistance properties of various subsoils are dealt with; then the various methods of subsoil exploration and sampling are described, including the vibration and geophysical methods. The third chapter deals with stress-distribution problems in the semi-infinite solid under various types of loading, while the stress distribution directly under the various footings and its influencing factors are introduced in the fourth chapter. Settlement analysis and calculation and the prevention measures against detrimental settlement are shown in the next two chapters. The last chapter concerns the ultimate bearing capacity of subsoils with its influencing factors.

The second volume starts with the design and dimensioning of various types of footing, and separate chapters deal with the dewatering and surrounding of working sites; bracing of open cuts, sheet-piling, pumping, cofferdams, well points, subaqueous concrete. These are discussed from both points of view, i.e., that of loads, design, and dimensioning and that of the practical execution. Then deep foundations are introduced: The various types of piling, their bearing-capacity theories and formulas, as well as the various kinds of fabrication, driving or boring, etc., methods. Then the various types of wells, shafts, and caissons are discussed, always from both the design and from the construction point of view. Pneumatic caissons and the various applications of compressed air in foundation engineering are described and extensively illustrated. Finally, the various artificial soil-stabilization—i.e., refrigeration, petrification, and compaction—methods and their use in foundation problems are introduced and an economical classification is given for the many possibilities and exigencies of the foundation engineer. At the end of each chapter the author gives some numerical examples to illustrate the practical use of the theory.

As a whole, the author made a successful effort to combine the rapidly developing theory of practical soil mechanics with the concepts of the design and practicing engineer confronted with the many and sometimes very unexpected problems of foundation engineering. The book is based on personal experience and experiments as well as on the most recent results of international literature and gives very comprehensive and practical information on foundation engineering as a whole.

G. Kazinczy, Sweden

392. **Arienti, R., Diesel motors on elastic foundations** (in Italian), *Ricerche* no. 1, pp. 27-50; *Suppl. Termotecnica* 7, 5, May 1953.

The design and testing of the suspension on helicoidal springs of a group of diesel motors are described in detail. Oscillograph records are presented which were taken both before and after the installation of the springs. The basic factors entering into the choice of method of suspension are discussed, as well as the number, use, and positioning of the springs, the analysis of the vibration characteristics of the spring-motors system, the design of the reinforced-concrete foundation, and the final experimental check. The entire work appears to have been carried out with great care and it should, therefore, be valuable to all interested in this type of problem, particularly from the practical engineering standpoint.

B. A. Boley, USA

393. **Seelye, E. E., Field practice**, 2nd rev. ed., New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, xvii + 394 pp.

Book is Vol. 3 of "Data book for civil engineers." Vols. 1 and 2 cover design, specification, and cost data [AMR 5, Rev. 1053]. Vol. 3, in convenient pocket size, aims to furnish the field or construction engineer or inspector with data frequently needed on the job. Major sections are construction equipment and methods, concrete, masonry, structural steel, welding, foundations, timber construction, soils, grading and paving, sanitary and drainage construction and surveying. Book contains check lists for inspectors, much useful descriptive material, and field-test procedures.

J. E. Goldberg, USA

394. **Merlino, F. S., A modified Hardy Cross method for the calculation of elastic frames** (in Italian), *G. Gen. civ.* 92, 2, 134-139, Feb. 1954.

Author employs successive approximations calculus both in the slope-deformation method and in the method of consistent deformation. In the first case, frames with forbidden joint movements are considered. Author derives the value of the joint rotation without distributing the unbalanced moment in the single step; hence some improvement on the classical procedure may be obtained.

Using the second method, any kind of indeterminate structure can be solved; the mechanical meaning of the single steps is emphasized. According to T. L. Wright's procedure, corrections of the unbalanced moments, or else of the inconsistent deformations, are chosen not fractional.

Examples of both cases are developed.

D. Gentiloni-Silverj, Italy

395. **Tsuboi, Y., Rigid frames and thin plates on lateral forces**, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; *Nat. Comm. Theor. appl. Mech.*, May 1952, 327-330.

The problem of a thin wall with four sides monolithically built in with a rigid frame formed by columns and beams is treated. The structure is subjected to either an earthquake or wind load, the reactions of which are assumed to be concentrated at the four

rigid corners of the frame. The author first treats the thin plate as a two-dimensional elasticity problem by expanding the Airy stress function into Fourier series, while the boundary stresses are specified and kept as parameters. Then the rigid frame is analyzed under the reactions due to the lateral load, and the boundary stresses transmitted by the plate. Finally, the conditions of continuity are imposed at the common boundaries of the frame and the plate; thus the parameters can be determined. A brief numerical example is worked out; the normal and shear stresses at the horizontal boundary and the shear stress at the midheight of the plate are plotted.

The reviewer believes that readers would be enlightened if the formulation of the problem and the boundary conditions were stated and the parameters which represent the essence of the results were given.

D. H. Cheng, USA

396. **Prager, W., Limit analysis and design**, *J. Amer. Concr. Inst.* 25, 4, part 1, 297-304, Dec. 1953.

In plasticity, distinction is made between limit analysis, which determines the carrying capacity of a given structure, and limit design, which is concerned with designing a structure to withstand given combinations of loads. Author gives the following procedure for the limit design of frames: Assume that P and Q are loads varying independently applied on the frame. A "domain of loading" is constructed with P and Q as rectangular coordinates. Then, this domain is circumscribed by a "safe domain" which expresses the resistance of the frame against collapse. The safe domain depends on the limiting moments of the bars of the frame. By circumscribing the one domain over the other, these limiting moments can be calculated.

A. Phillips, USA

397. **Franciosi, V., Limit analysis of a Nielsen truss** (in Italian), *G. Gen. civ.* 92, 3, 202-212, Mar. 1954.

The two basic principles (static and kinematic) of Prager are applied in the limit analysis of a structure, in which moments are not dominant with respect to axial forces. This determines that fully plastic moments must be corrected for axial forces, and the problem is solved step by step.

Two cases are studied: (1) proportional loading; (2) there is a permanent load and an accidental one (but fixed in position). The second is increased up to collapse. In both cases the "safety factor" is obtained by introducing some simplifications in the solutions of the resulting systems. Numerical examples are added for both studies.

Reviewer found the work very interesting but wishes to point out (1) that supposing a fixed position for the accidental loading, as author does, is not realistic, and the safety factor obtained is referred to the position supposed; (2) the real safety factor for an accidental load should be obtained through a "shake-down" analysis; (3) author should explain how he chose the values of safety factors in the second trial. Once 1.50 is chosen to get 1.31, and then 1.90 to get 1.86—in both cases after a first trial with 2 as value of safety factor.

A. J. Bignoli, Argentina

398. **Levi, F., Investigation of anelastic phenomena up to rupture** (in Italian), *G. Gen. civ.* 92, 3, 180-192, Mar. 1954.

Adopting a bending-moment-curvature diagram composed of three straight lines, and applying the principles of elastoplastic equilibrium, author predicts the behavior of concrete beams, fixed at both ends, in plastic bending. In the ordinary analysis of continuous structures in the failure range, it is assumed that fully plastic moments are developed, and the problem of plastic collapse is reduced to finding the location of the so-called "plastic hinges" at the critical load. This is a simplified analysis, and no

attention is paid to the real redistribution of movements that takes place in the structure.

Author's paper is directed toward a deeper understanding of the process of redistribution of moments in fixed beams. Author's analysis leads to the conclusion that fully plastic moments appear as limiting values that are reached only in case the beam has enough capacity to develop large plastic strains without failure. The paper includes also a brief discussion of the fundamental concepts and basic assumptions involved. Reference is made to tests performed with prestressed continuous beams. It is claimed that more experimental evidence supporting author's theory will be presented in a forthcoming paper, containing a complete report of the mentioned tests.

In reviewer's opinion, this is a well-written paper. Further research is needed to determine more closely the values of some of the factors involved. However, author's theory may have considerable value in guiding further research.

C. A. Sciammarella, Argentina

399. Magini, O., On the bending of thin wall hollow rectangular prisms of reinforced concrete with equally distributed longitudinal reinforcement (in Italian), *Atti Ist. Sci. Costr. Univ. Pisa* no. 29, 27 pp., 1953.

This paper deals with the design of reinforced-concrete square tubes loaded by bending. The bending can be applied on the axis connecting the middle points of the sides of the square or on the diagonal. The stability of the thin wall of the tube is taken into consideration. Several tables are included which will prove useful to designers.

A. J. Durelli, USA

400. Gvozdev, A. A., Deformations in massive concrete blocks caused by temperature and shrinkage (in Russian), *Izv. Akad. Nauk SSSR Otd. tekhn. Nauk* no. 4, 493-504, Apr. 1953.

A method of calculating stresses in concrete blocks is given, permitting establishment of a pouring program on large works. Thermodynamics of exothermic cement and creep of concrete are discussed. Analysis is by integral equations and operational calculus. Heat generation under adiabatic and isothermal conditions is related to practical problems and experimental curves are plotted.

Reviewer believes paper is important because of treatment of heat evolution in concrete, but results are in a form not immediately useful to a practicing engineer.

V. L. Dutton, Canada

401. Mohammed, I. A., and Popov, E. P., Beam restraints provided by walls with openings, *Proc. Amer. Soc. Civ. Engrs.* 80, Separ. no. 529, 28 pp., Oct. 1954.

Paper presents a solution to the problem of the end restraint provided by a wall to a beam framing into it. Linear plate theory is used to effect a solution for the case of a beam framing into a solid rectangular wall not having cutouts. Experimental data are presented for the magnitude of the restraint when the wall is pierced with various sized openings. At the end of the paper an example illustrating the use of the theory and experimental results is given.

W. J. Carter, USA

402. Tottenham, H., A simplified method of design for cylindrical shell roofs, *Struct. Engr.* 32, 6, 161-180, June 1954.

Structure is divided into two parts: shell and edge beams. Based on Schorer's approximate differential equation [*Proc. Amer. Soc. Civ. Engrs.* 61, 281-316, 1935], influence coefficients are calculated and tabulated for edge displacements on the shell for uniformly distributed loads and for tangential, radial, and axial (shear) edge loads. Equating edge displacements of shell expressed in terms

of external load and unknown edge loads to displacements of edge beam, three equations are obtained for calculating edge loads. Coefficients tabulated for most frequently encountered shell dimensions permit evaluation of forces in shell at four points by slide-rule calculations. Application of method to design of a reinforced-concrete shell is illustrated by a fully worked example, for which a comparison is given with the more exact solution by Jensen's method.

G. Sved, Australia

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 341, 366, 368, 369, 372, 385, 386, 396, 424, 522, 525)

403. Meixner, J., Thermodynamic theory of elastic relaxation (in German), *Z. Naturforsch.* 9a, 7/8, 654-663, July/Aug. 1954.

Phenomenological theory of relaxation phenomena for isothermal and adiabatic aftereffects, based on function-theory methods, is nearing completion. Still missing was a consequent thermodynamical theory that would also include temperature and entropy aftereffects and a treatment of energy relations. This theory is developed in present paper. Suitable internal variables are introduced; the afterfunction (sometimes called hereditary function) is substituted by an aftermatrix. Establishment of equilibrium conditions and internal transformations are treated by method of nonequilibrium thermodynamics. Restriction to small deviation from equilibrium allows linearization of theory and thus facilitates mathematical treatment. The correspondence of the concepts of phenomenological and thermodynamical theory is discussed. Finally, important and very general conclusions about relaxation spectra and relationships between them are obtained.

B. Gross, USA

404. Frankland, J. M., and Roach, R. E., Strength under combined tension and bending in the plastic range, *J. aero. Sci.* 21, 7, 449-453, 474, July 1954.

From a linear strain distribution over the section and the Ramberg-Osgood expression for the stress-strain curve, non-dimensional interaction curves between axial load and bending are derived. As an approximation it is assumed that the transverse contraction is half of the longitudinal extension and that the distorted section is a trapezoid, thus neglecting anticlastic curvature and anisotropy of plastic flow. Strength is presented in terms of allowable plastic strain at the extreme fiber. It is also shown how the change of curvature under load may be obtained, and suggestions are given for the use of this to calculate strength under statically indeterminate conditions. More specified experimental evidence than is given in the paper would be desirable, in reviewer's opinion.

Further, reviewer believes that more emphasis should have been laid upon the restriction that the results of the paper hold only when axial load and bending act simultaneously and increase in such a way that no strain reversal takes place. This condition imposes limitations upon the ratio of the axial load and the bending moment in the loading process, which are not given.

J. F. Besseling, Holland

405. Hill, R., On the limits set by plastic yielding to the intensity of singularities of stress, *J. Mech. Phys. Solids* 2, 4, 278-285, June 1954.

In addition to stress equilibrium, velocity compatibility, and yield conditions, there are other conditions to be satisfied by any solution in the plane flow of a plastic-rigid material. These are: (a) that the rate of working must be everywhere positive in the

zone of deforming material, and (b) that the criterion of yielding must not be exceeded in the neighboring rigid zones.

In a recent paper, A. P. Green [AMR 7, Rev. 3206] described a rapid method of assessing (a). The present analysis, another valuable contribution to plasticity theory by Professor Hill, enables the rapid assessment of (b), which has not hitherto been possible. The author considers an idealized two-dimensional wedge of vertex angle α , whose boundaries are subjected to arbitrary normal and shear stresses tending to finite limits as the vertex is approached. The limitations on both α and the normal stresses on each boundary are then determined for given values of the boundary shear stresses, in order that the criterion of yielding (von Mises) shall not be exceeded in the vertex.

Application of this test to any proposed solution is simple, since the author has detailed all cases which normally arise. The boundaries of the rigid material adjacent to deforming material normally form a wedge on whose surfaces the stresses are prescribed by the proposed solution. The values of the shear stresses on these surfaces impose limitations on both the wedge apex angle and on the difference between the normal stresses, if the wedge is to remain rigid, and these limitations are set out clearly for specific cases.

The author shows that two previous solutions, to the problems of indentation by a rough wedge and of machining, are disproved by this new consideration. In conclusion he exhibits the two possible slip-line field solutions for flow in the wedge and thereby rederives the required yield-point relations. Reviewer considers that most cases will be readily assessed by this analysis; possible exceptions are those problems in which external loads are transmitted through rigid zones so that the stresses are unknown on one side of the wedge. This problem has been considered by J. F. W. Bishop [AMR 7, Rev. 1793].

J. M. Alexander, England

406. Zanaboni, O., Bending in the elastoplastic region: general analytical treatment (in Italian), *G. Gen. civ.* 92, 4, 245-258, Apr. 1954.

Author considers bending of the beam of any cross section. He uses complicated differential procedure to give results obtainable from better known and simpler methods.

D. R. Bland, England

407. Kostiuk, A. G., Creep strength in rotating disks (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* 15, 15-20, 1953.

First part of paper contains derivation of differential equations for stress distribution in a rotating disk of nonuniform thickness, based upon Ilyushin's theory of plasticity [see AMR 2, Revs. 731 and 1503; 3, Rev. 1263], taking account of thermal expansion due to nonuniform temperature distribution of rotational symmetry. Integration is carried out using a method of successive approximations, starting from an assumed distribution of circumferential stress, time occurring as a parameter. Numerical calculations for a disk of conventional tapering profile show results of three first approximations. Second part of paper specializes on a disk of hyperbolic profile and takes total creep strain proportional to time and to a power of effective stress, the exponent n being independent of time and temperature. Integration is carried out, making use of assumptions so as to linearize differential equations for radial stress. Computations for special case of a disk of uniform thickness show solutions for $n = 2$ and $n = 11$. As paper is written in a highly condensed form, reviewer feels unable to express an opinion about validity of underlying assumptions. Thus, for example, the fundamental assumptions of second part are known to hold with some degree of approximation for real materials only in case of effective stress independent of time.

F. K. G. Odqvist, Sweden

408. Kochetkov, A. M., Stresses in a wedge under the influence of hydrostatic pressure (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* 15, 177-180, 1953.

In the title problem the wedge is assumed to consist of plastic material of the deformation-theory type with an exponential strain-hardening relation. Stresses and deformations in such a wedge are expressed in terms of four functions whose determination is indicated in implicit form. In the case of a linear stress-strain law the solution is said to reduce to that of the elastic case in closed form. Some numerical results are presented in graphical form.

G. Winter, USA

Failure, Mechanics of Solid State

(See also Rev. 368)

409. Caswell, J. S., Machine design for cyclic stress. Parts I, II, III, *Engineer, Lond.* 198, 5145, 5146, 5147; 318-321, 346-349, 378-381, Sept. 1954.

First part is exposition of standard material on cyclic stresses, Goodman diagram, factor of safety, design formulas, etc. In second part, author takes issue with standard practice as regards design for oscillating stresses and proposes to bring into account steady mean stress as well as oscillatory amplitude, which leads to new design formula whose use he illustrates. Third part extends formula to shear stresses and derives formula for more realistic alternating stress diagram. It is stated that the derived formulas make provision for counteracting effects of stress concentration and also for taking some account of effect of quality change between test specimen and service part.

G. W. Housner, USA

410. Lushey, R. S. D., and McKeown, J., Stress-rupture time properties of copper tube materials, *Engineer, Lond.* 197, 5132, 811-813, June 1954.

The work described in this article has been carried out to provide stress data on which engineers might base their calculations of suitable wall thicknesses for copper tubes subjected to internal pressure. The data are of use for tubes for engineering applications at ordinary temperatures, where it is suspected that the safety factor used with tensile strength may be unduly conservative. Any proposals for an increase in design stress must be coupled with an assurance that there is no risk of failure with small expansion of the tube.

From authors' summary

411. Weck, R., Fatigue of welded structures, *Struct. Engr.* 32, 4, 115-129, Apr. 1954.

Steel construction, submitted to a large number of loading cycles, requires an intense study of fatigue life and sometimes suffers fatigue failures. Author presents an extensive review of actual status in practical experience and investigation, which—though it does not contain new knowledge for the expert—may be considered as a very profound study of a serious problem. He underlines importance of adequate choice of material and appropriate design of structures, such as railway bridges, gantries, machinery structures, presenting good and bad executions. Special attention is given to the notch effect in riveted and welded joints, which is the most important reason for fatigue failures. Designers must become intensely "notch-conscious." Author shows details of welded structures such as plate girders, trusses, and lattice girders, generally preferring butt-welded joints with inserted transition pieces and avoiding "egg-boxes." British standard has to be modified, taking into account actual status of investigation and experience. Reviewer points out that some

European standards possess detailed specifications for welded structures under stress variations, including notch effect and type of welding.

H. Beer, Austria

412. Schijve, J., The possibilities of internal friction measurements for material testing, in particular for fatigue testing (in Dutch), *Nat. LuchtLab. Amsterdam Rap. M.* 1949, 27 pp., 2 tables, Apr. 1954.

This survey of present knowledge on internal friction and damping capacity of metals is based upon 30 papers published 1937-1953.

Included are causes of internal friction, description and principles of methods and equipment used for quantitative measurement.

Several important properties in relation to microstructure may be investigated successfully. In particular, the progression of intercrystalline corrosion may be followed clearly.

An evaluation of fatigue damage would appear possible at first sight, but results obtained so far have been rather discouraging. A certain correlation between damping capacity and fatigue damage has been shown to exist, but the nature of this correlation is too complex to permit any predictions regarding the lifetime of a structure stressed in fatigue.

H. Vinter, Denmark

413. Schaden, K., Rupturing bending moment of beams, with two supports, of plastic, brittle, and compound material (in German), *Öst. Ing.-Arch.* 7, 4, 284-289, Nov. 1953.

Using the relationships established by A. Nadai ["Theory of flow and fracture of solids," New York, 1950], a general expression is derived for the ultimate strength of simply supported beams of I, Z, and rectangular cross-sectional area and of simple or compound materials of known stress-strain relations, such as steel or reinforced concrete. The ultimate bending moment M is defined by the equation $dM/d\theta = 0$ (θ angle of inclination of two cross sections). Stress-strain curves are determined using experimental values taken from the tests of C. Bach and are compared with those obtained by tension and compression tests. The derived equation for the ultimate bending moment is applied to data of tests pertaining to several European researchers. Numerical results show good agreement between computed and experimental values.

Reviewer believes that author's purpose is far from being achieved and that it is possible to point out several disagreements between author's theoretical assumptions and experimental facts and the lack of proof of many of the author's statements. In the analysis of the C. Bach test of a beam without reinforcement, author's adopted values are inconsistent with those measured. Author tries to explain these differences with unsatisfactory reasonings over the strain-measuring procedure employed in the test. The same test has been analyzed by E. Mörsch ["Der Eisenbetonbau," vol. I]. Mörsch's values are closely coincident with those measured and give a satisfactory relation between the failure stresses in the top and bottom fibers (2), while author's assumed values give a very low relation (1.44). Author's derived formulas for reinforced beams give low values for the failure bending moment. To make the computed values conform to beam tests, author introduces the contribution of the concrete in tension at failure. As the analyzed tests have been carried out—applying the loads in steps and discharging at every step—the contribution of concrete is assumed to be in the same relation of the last load step to the failure load. Author gives no proof for this statement other than the numerical agreement between computed values and test data [see AMR 5, Rev. 2341].

The discrepancy found in the analysis of the C. Bach test of a nonreinforced beam may be clearly explained on the basis of the

author's chosen mathematical definition for the failure bending moment. The relation $dM/d\theta = 0$ holds for materials that are characterized by an idealized trapezoidal stress-strain curve with a range of comparatively large permanent elongations in which the load will stay practically constant (ductile steels). This is not the case of a brittle material like concrete. Also it is necessary to draw the author's attention to the fact that the measured strains in the tension zone of the reinforced beams are mean values, because the gage length includes several cracks where the strains of the reinforcement are localized. Cracks affect decisively the magnitude of the tensile forces in the reinforcing bars, and strains in the cracks are larger than those measured in a conventional tension test with long specimens because the necking zone is significant in relation to the length submitted to tension. Maximum strain values, and stress-strain curves measured in very short specimens, should be used for finding the maximum load-carrying capacity of a beam, applying the author's derived formulas, and not mean values, and stress-strain curves obtained from conventional tensile tests.

In spite of the defects mentioned (and some others, including minor misprints), this paper is an interesting contribution to the theory of plastic design of reinforced concrete.

C. A. Sciammarella, Argentina

414. de Kazinczy, F., A theory of hydrogen embrittlement, *J. Iron Steel Inst. Lond.* 177, 1, 85-92, May 1954.

Hydrogen embrittlement is caused by a lowering of shear strength and cleavage strength. This can be explained by assuming that molecular hydrogen of high pressure is included in a Griffith crack or some other crack, which initiates fracturing. During crack spreading, the gas expands and releases energy, which results in a lowering of the fracture stress. It is shown that hydrogen diffusion into the crack is needed during crack spreading by which the time and temperature effect of hydrogen embrittlement can be explained.

From author's summary

Material Test Techniques

(See also Revs. 358, 369, 388, 410, 412, 419)

415. Brown, A. F. C., Triaxial stresses caused by notches, *Brit. J. appl. Phys.* 5, 8, 280-284, Aug. 1954.

It is proposed that notched specimens be used to determine brittleness of ductile materials. Triaxial stresses produced in notched specimens tend to suppress the plastic deformation. Cylindrical specimens with V-grooves were subjected to axial static loads. The ratio of the 1% proof stress (yield strength) of the notched specimens to that of an unnotched specimen is defined as the "triaxiality ratio" of the notch and is designated as n . A large value of n indicates a reduced effect of yielding at base of notch. Values of n are tabulated and plotted for various depths of notch and various radii at the base of the notch in low-carbon steel specimens. Stresses are determined at interior points using photoelastic frozen stress techniques and Fosterite models. These results indicate that n depends on state of stress at center of specimen rather than at base of notch. A notched beam is also tested using frozen stress methods.

W. B. Stiles, USA

416. Habicht, F. R., Static, dynamic, and x-ray investigation of toothed-ring connectors (in German), *Bauingenieur* 29, 4, 126-132, Apr. 1954.

Six three-member joints of pine lumber of 19% moisture content—assembled with one 3/4-in.-diam steel bolt and one pair of 4-in.-diam alligator connectors between the 2-in.-thick side members and 4-in.-thick center member—were subjected to static and

repetitive (up to 443, 100) loading tests and x-ray examination during the various loading stages. The joint members were loaded (1) parallel, (2) perpendicular to grain, or (3) with the center member parallel to grain and the side members perpendicular to grain.

While dial gages indicated the relative movement of the joint members, that is, measured the joint deformation, the x-ray photographs showed the deformation of both bolt and connectors within the joints during load application.

The well-illustrated paper presents complete details on testing procedure and step-by-step test progress. It correlates total joint deformation with bolt deflection and connector deformation.

E. G. Stern, USA

417. Norris, H. B., The correlation of the betatron with other forms of non-destructive testing, *ASTM Bull.* no. 197, 56-57, Apr. 1954.

The betatron radiation of 24 mev, which easily penetrates over 20 inches of steel, permits obtaining radiographs with a sensitivity of approximately 0.5%. The betatron supplements the other methods of nondestructive testing. Surface defects found in a casting by magnetic particles are often found to be acceptable when retested by the betatron. Conversely, defects found by the betatron may be acceptable when they are found by magnetic methods to be internal defects. Complex assemblies of sheet-metal weldings for aircraft are tested by low-voltage x-ray equipment in detail and are radiographed by the betatron as a whole, with a simple exposure giving satisfactory pictures if the accumulated thickness of the material is over 1 inch. Defects found with the betatron are often controlled by ultrasonics in the process of repairing. Author correlates the betatron test with visual tests.

O. Ruediger, Germany

Mechanical Properties of Specific Materials

(See also Revs. 389, 390, 393, 504)

418. Clare, K. E., and Pollard, A. E., The effect of curing temperature on the compressive strength of soil-cement mixtures, *Géotechnique, Lond.* 4, 3, 97-107, Sept. 1954.

The influence of the curing temperature on the compressive strength of cylindrical specimens of soil cement has been studied at ages up to 3 months. Five soils—a clay, a silty clay, two sands, and a gravel—were used, being stabilized with 10% of ordinary Portland cement (15% for the clay). Methods have been developed for coating or enclosing the specimens to prevent changes in their moisture contents during curing at temperatures up to 140 C.

From authors' summary

419. Chatterjee, G. P., Hardness of metals and alloys, *Indian J. Phys.* 28, 1, 9-20, Jan. 1954.

Author defines hardness H as work done per unit volume of indentation in a Brinell test. Assuming validity of Meyer's law $W = k \cdot d^n$ (W load, d chordal diameter of the remaining indentation, k and n constants of materials), he finds $H = k \cdot f(n) \cdot f(n)$ is a known function of n and ratio s/D (D diameter of ball). Measurements of diameters d_1 and d_2 under loads W_1 and W_2 give values of n , k , and $f(n)$. Experiments show agreement of values of H (expressed as kg mm/mm²) with the Brinell hardness numbers (expressed as kg/mm²) for many pure metals and alloys.

H. Mussmann, Germany

420. Needham, R. A., The ultimate strength of aluminum-alloy formed structural shapes in compression, *J. aero. Sci.* 21, 4, 217-229, Apr. 1954.

A new method of predicting the maximum average (crippling)

stress of formed sheet-metal structural shapes in compression is presented. The proposed method is based on the assumption that a formed structural shape consisting of a series of flat plate elements can be treated as a series of angle sections possessing various degrees of edge support parallel to the direction of loading. A weighted crippling stress of the formed structural shape is obtained by summing the crippling loads of the individual angle sections and dividing this summation by the gross area of the structural shape.

Empirical equations for predicting the crippling stress of the basic angle sections were obtained from the analysis of approximately 200 tests of formed angles and channels of 24S-T3 and 75S-T6 aluminum-alloy sheet. The proposed method of analysis was applied to 24 typical aircraft stringer shapes. The agreement of the predicted and test crippling stresses was found to be very good.

From author's summary

Reviewer's comment: This method appears very successful for short members (slenderness ratio less than 20), but no suggestion is given on procedures to determine the effects of length.

Marshall Holt, USA

421. Friedman, R., High-temperature durability of molybdenum in oxygen-deficient combustion gases, *Jet Propulsion* 24, 3, p. 187, May-June 1954.

Molybdenum parts might be used in the combustion chambers or turbine blades of gas turbines if the corrosion rate could be maintained at a sufficiently low level. Test data are reported for exposure of uncoated molybdenum to oxygen-deficient combustion gases to 2600 F, showing that corrosion rates are low enough to be tolerated in many applications.

From author's summary

422. Ault, G. M., and Deutsch, G. C., Applicability of powder metallurgy to problems of high temperature materials, *J. Metals* 6, 11, sec. 1, 1214-1226, Nov. 1954.

Paper reviews the efforts made to utilize powder metallurgy to solve problems encountered when using alloys at high temperatures. The following subjects are discussed: Comparison of wrought and sintered super alloys, sintered aluminum powder, porous materials for transpiration cooling, molybdenum, and cermets.

From authors' summary

423. Dietz, A. G. H., High-strength plastics, *Proc. nat. Acad. Sci. Wash.* 40, 3, 157-161, Mar. 1954.

Paper discusses high strength plastics in general terms: their constituents, their nonisotropic physical characteristics, merits, and prospects in research, design, and applications.

A.-t. Yu, USA

Mechanics of Forming and Cutting

424. Willis, J., Deep drawing, London, Butterworths Scientific Publications, 1954, x + 134 pp. 25 s.

This British book is a summary of the practical areas of Professor H. W. Swift's researches on forming sheet metal at Sheffield University over a span of 17 years. Detailed description is given in chap. 1 on the experimental presses built by Professor Swift, starting with his first subpress built in 1937. It had a punch diameter of 2.00 in.

A summary on deep-drawing theory in chap. 2 considers four operations with allowance for strain hardening: (1) Drawing-in of the flange while pressing over the face of the die; (2) bending of the material over the die radius, and its subsequent unbending to form the walls of the cup; (3) stretching and thinning of cup

walls; (4) stretching of the center of blank over the punch profile.

No detailed derivations are given; thus one concludes there are many empirical formulas in use. Description of a special jig reveals that steel strip could be bent under tension. Surprisingly, it thinned, due solely to bending as it passed over the die profile. Furthermore, the size and shape of die profile have an influence on the residual stresses left in drawn cup. Season cracking is related to the residual stresses. Author stated that tests correlated well with theory.

In chap. 3, single-stage drawing is considered with a discussion of tool design. Some of the practical conclusions are: (a) Optimum ratio of die profile radius to blank thickness appears to be about 10; (b) a pressure plate prevents wrinkling in drawing very thick plates and permits larger blanks to be drawn as well as the deepest draw with either constant clearance or constant pressure; (c) either parallel-throated dies or tapered dies may be used with steel, stainless steel, or brass, but only a small taper may be used with copper and aluminum; (d) best taper for ironing was a 15° semi-cone angle; (e) punch profile greatly influences the thickness distribution, a round-ended punch giving more general one, instead of localized thinning.

Chap. 4 indicates some of the problems involved in industrial pressings of more than one stage. Use of guide sleeves was investigated. Tapered dies give certain benefits on redrawing if suitable clearance is provided, even though the use of tapered dies in first-stage drawing shows puckering. The deepest combined drawing ratio obtainable from a two-stage operation is obtained always when the first cup is drawn as deeply as possible. Redrawing performance is distinctly improved by annealing.

During reverse redrawing the best die profile is a semi-circular one. With an external guide sleeve at the entrance of a direct redrawing die, the punch load is less than on reverse drawing as well as producing the least thinning.

Ironing effects on the cylindrical cups are revealed through experiments described in chap. 5. Only the die-cup interface requires lubrication. Most suitable taper for ironing dies is 15° because of reduced loads and better size maintenance. Residual stresses are smaller and more uniform than those in similar unironed cups, which means season-cracking is less likely.

The shearing of metal bars and blanks is discussed in chap. 6. Studies were made on shear fractures of thick bars having virtually no clearance but using scribed lines to follow progress of shearing. Load-penetration curves are presented for aluminum, mild steel, copper, tin, and lead showing the effects of various amounts of clearance. In tin and lead, sliding occurs along the plane of shear until severance occurs at full penetration, whereas aluminum and copper cracks develop at an angle to the plane of shear. Steel under shearing action formed tongue cracks at an angle to the plane of shear.

Chap. 7 explains the work on subpresses to determine the effectiveness of several lubricants. Brown-soap solution on a bonderized surface gives the best compromise between easy cleaning of the deep drawn cups and good anti-friction properties. For all lubricants, best results are obtained when the nose of the punch and that part of the blank in contact with it are kept completely free of lubricant.

A general conclusion reached on the shape of the die in chap. 8 is that all work-hardened materials draw better with flat-ended punches than with round-ended ones; and all soft materials draw better on round-ended ones than with flat-ended ones. To obtain the deepest draws on both punch shapes, soft materials should be used. Current work is in progress at Sheffield University with the influence of biaxial tension and friction over the punch head on drawing.

Chap. 9 indicates the difficulties of simulative tests for assess-

ment of deep-drawing materials. In England the Erickson cupping test has been adopted to some degree; no correlation was obtained with this test and the cupping performed on a subpress. Sachs and Ekergram wedge tests are compared with those by Swift, and it is concluded that some form of genuine drawing operation must form the basis of any test to assess drawing operations. A description of an experimental drawing press follows.

The concluding chap. 10 is a summary of practical findings for cups of cylindrical shape.

H. Majors, Jr., USA

425. Hoff, H., and Dahl, T., *Rolling and roll design* [Walzen und Kalibrieren], (Stahleisen-Bücher, Bd. 12), Düsseldorf, Verlag Stahleisen M.B.H., 1954, xi + 216 pp., 202 figs., 63 tables, DM 22.50.

One of a series of twelve volumes on steel manufacturing, the book is a well-written reference and text on design of rolling mills with emphasis on the stepwise procedure of cross-section layouts for various rolled shapes. It is arranged in four parts. Part 1 is a general discussion of rolling processes and shows equations for finding changes in cross section and length of rolled stock. Part 2 describes configuration and measurements of double and triple roll-stands as well as rolling of billets in continuous mills. Charts and equations for square and rectangular barstock as well as flat plate rolling are shown in part 3. The last part of the book describes rolling of structural shapes and wire rolling and closes with a discussion of arrangements and layouts for various rolling mills. Large number of practical examples of roll design together with select bibliography makes text a useful reference for design engineers.

J. Frisch, USA

426. Peck, C. F., Jr., Bonetti, F. M., and Mavis, F. T., *Temperature stresses in iron work rolls*, *Iron Steel Engr.* 31, 6, 45-58, June 1954.

Paper consists of two parts: finding the temperature distribution in the rolls when cyclic equilibrium is reached, and determining the stresses for the temperature pattern. The thermal problem is solved as one-dimensional problem, i.e., disregarding heat conduction both in axial and in circumferential directions. Method is that of finite differences. But since boundary conditions are not known, authors assume relative values of surface temperature distribution. They compare the total heat absorption of the roll in cyclic equilibrium with values found in practice, and thus obtain a correction factor for the temperature distribution.

Reviewer believes that disregard of circumferential heat flow tends to flatten the temperature profile. At the points of roll not in contact with the sheet, zero boundary conductance is assumed, which is incorrect and results in too low a roll temperature. The greatest weakness seems to be in the arbitrary assumption of initial temperature distribution. The same total heat extraction could be obtained with a different temperature distribution.

The thermal stresses are also determined numerically. The outer heated rim of the roll is developed and considered as a plate. The effect of the remainder of the roll is simulated by fixed supports. The plate is subdivided into rectangles which are assumed at uniform temperature, and the forces on the faces of these rectangles to prevent expansion are computed. The stresses due to the application of a complementary force system to remove unbalanced stresses on the interfaces are also computed numerically and the final result obtained by superposition. The exposition of the procedure is not precise.

V. Paschkis, USA, and J. H. Weiner, USA

427. ten Horn, B. L., and Schuermann, R. A., Chip control—how to determine tool feed to obtain desirable chip form, *Tool Engr.* 33, 4, 37-44, Oct. 1954.

428. Marriner, R. S., The manufacture of aerofoil models by tangent plane milling, *Aero. Res. Coun. Lond. curr. Pap.* no. 166, 20 pp., June 1953, published 1954.

Hydraulics; Cavitation; Transport

(See also Revs. 361, 445, 470, 530, 537, 539)

429. Silber, R., Study and tracing of steady flow in canals and rivers [Étude et tracé des écoulements permanents en canaux et rivières], Paris, Dunod, 1954, xiv + 194 pp., 180 figs., 1 diagram. 1800 Fr.

Book is an exposition of a graphical-analytical method proposed by the author for tracing steady-flow profiles of free surface currents. Method is based on a systematic employment of a curve, which author calls "universal," representing the equation $Q = l_m h 2g(H - h)^{1/2}$ in a dimensional form (h depth, l_m average breadth of the liquid section, H total head): the reduction to a dimensional form is made, assuming as reference lengths a particular total head and, for nonrectangular sections, the average breadth (this is perhaps the more interesting innovation). A curve of the hydraulic jump, rigorously valid only for rectangular sections, completes the diagram, allowing the study of situations with discontinuities. On the diagram, the successive steps of the flow are followed along lines (straight lines for rectangular canals and constant discharge) called "utilization lines."

Exposition of the method is followed by a long exemplification, which is an interesting recapitulation of well-known things. Some conceptual, mainly practical, interest is attached to the analysis of particular situations, including sections with critical slope; and some novelty enters the study of flow in canals with closed sections (nevertheless not original).

Book is not without errors and imperfections in formulas and figures. D. Citrini, Italy

430. Knapp, R. T., Present status of cavitation research, *Mech. Engng.*, N. Y. 76, 9, 731-734, Sept. 1954.

431. Olsson, R. G., A modification of Chezy's formula of hydraulics, *K. norske Vidensk. Selsk. Forh.* 26, 15, 61-63, 1953.

Defining the Reynolds number R as the square of the ratio of mean velocity and mean shear velocity, author shows that Chezy's C is equal to $(Rg)^{1/2}$, in which g is the gravitational acceleration, and points out that the flow in a wide channel is "tranquil" or "shooting," depending on whether the product Ri (i is slope of channel) is smaller or greater than 1. Author compares the significance of Ri in flow in a wide open channel with that of the Mach number in compressible flow, but fails to mention that Ri is nothing but the square of Froude number so familiar to hydraulic engineers. C.-S. Yih, USA

432. Serre, F., Contribution to the study of steady and nonsteady flows in channels (in French), *Houille blanche* 8, 6, 830-872, Dec. 1953.

Applying his analysis including curvature effects [see AMR 7, Rev. 1515], author studies the following cases: (1) Channel in uniform regime at infinity upstream and with given depth at the downstream section. Significant result: the undulated jump for supercritical regime. (2) same problem with two slopes, mild upstream, steep downstream. Behavior at the junction. (3)

Channel with a gate upstream, in uniform regime downstream. Approximate surface profile near the gate. Influence of the downstream condition and wave formation. (4) Broadcrested weir. With friction, neglected conoidal waves are found and related to the flow conditions. Experiments by Tison are analyzed in this approximation and also with friction included; agreement is good.

Last part of the thesis concerns the nonsteady flow. After establishing general equations (again close to Boussinesq), author concentrates on progressive waves.

Although some known results are rediscovered and some need further research, reviewer recommends this paper as being of real research value. A. Craya, France

433. Dzhimsheli, G. A., Channels of complex section with maximal efficiency (in Russian), *Gidrotekhn. Stroit.* 22, 11, 36-39, Nov.-Dec. 1953.

Problem of the best hydraulic section of an open channel is solved for nonsymmetrical trapezoidal section with varying side slopes, which is sometimes preferable in practice. Introducing different ratios, a solution is offered similar to that for a simple trapezoidal section. Size of channel can be easily computed, requiring minimum excavation costs, disregarding, however, costs of lining and different roughness of the walls.

S. Kolupaila, USA

434. Starostin, M. G., Basic properties of circulating currents in straight channels (in Russian), *Gidrotekhn. i Melior.* no. 7, 16-24, July 1953.

Transverse components of velocity in a cross section are investigated and two extreme types are represented, namely, a plain circulating motion in cross section and an onward helicoidal motion. All uniform currents have usually transverse circulations. Practical application of theory: control of bed erosion and silt protection in inlets.

S. Kolupaila, USA

435. Uginchus, A. A., Design of channels with polygonal cross section (in Russian), *Gidrotekhn. i Melior.* no. 7, 25-32, July 1953.

Computation of a best hydraulic section is allowed for compound form of channel, after different side slopes are replaced by one equivalent slope.

S. Kolupaila, USA

436. Kvardakov, A. F., Methods of determination of the critical depth in trapezoidal channels (in Russian), *Gidrotekhn. i Melior.* no. 7, 39-44, July 1953.

Eleven Russian methods are compared in respect to their convenience and time of computations. This article shows that Russian hydraulic engineers are unaware of progress abroad: universal and more convenient American methods are unknown or intentionally disguised.

S. Kolupaila, USA

437. Sokolovskii, D. L., Methods of runoff computation in design of drainage systems (in Russian), *Gidrotekhn. i Melior.* no. 6, 3-10, June 1953.

Rational and empirical formulas are compared and their variables suggested for computation of runoff during drainage season.

S. Kolupaila, USA

438. Girshkan, S. A., Silt-transporting capacity of canals (in Russian), *Gidrotekhn. i Melior.* no. 6, 49-54, June 1953.

Formula for design of nonsilting canals is offered, based on the prevailing size of transported substances. Carrying capacity is proportional to discharge $Q^{0.4}$ and slope s .

S. Kolupaila, USA

439. Shablinskiĭ, V. V., and Burlakov, V. E., Design of open channels of curvilinear cross section (in Russian), *Gidrotekh. i Melior.* no. 5, 37-44, May 1953.

Parabolic and hyperbolic sections are investigated, as closest to the natural channels. Formulas are developed and diagrams for computation presented; easy design of complicated forms is allowed.

S. Kolupaila, USA

440. Schultze, E., Excess hydrostatic pressures behind quay walls, *Wys. Exp. Sta. Transl.* no. 54-5, 65 pp., Sept. 1954 (translated by Van Tienhoven, J. C.); *Houille blanche* 7, 809-835, 1952.

The two-dimensional flow due to tidal water-surface fluctuations under and behind quay walls is approximated by the one-dimensional flow in a narrow layer of porous material of constant thickness around the structure. Methods are indicated according to which the constants of this layer may be chosen. The effectiveness of the method is demonstrated by a number of examples.

The approach appears to be logical since, for low permeability of the ground, the entire flow is concentrated to the immediate neighborhood of the wall, while for high permeability, where the effective flow field is larger, there exists no excess pressure problem.

H. A. Einstein, USA

441. Pikalov, F. I., Submergence criterion for a broad-crested weir (in Russian), *Gidrotekh. i Melior.* no. 10, 50-57, Oct. 1953.

Transition from free to submerged overflow can be defined by comparison with the equivalent depth of hydraulic jump. Coefficient of discharge is determined in terms of the coefficient of velocity.

S. Kolupaila, USA

442. Grzywiński, A., Floods and their storage by, or discharge from, large dams (in German), *Öst. Bauzeitschr.* 8, 8, 9, 10; 137-144, 157-159, 173-176, Aug., Sept., Oct. 1953.

Author sums up and comments on more than 1000 pages forming reports concerning question in title (point 12) presented to The Fourth International Congress on Large Dams in New Delhi, 1951. Paper gives references on different subquestions—such as hydrologic investigations, peak flow, size of flood for project, storage and its influence on flood flow, required capacity and construction of spillway—and is thus valuable to engineers who want general information of construction practice or special information details.

H. T. Kristensen, Sweden

Incompressible Flow: Laminar; Viscous

(See also Revs. 440, 463, 505, 507, 530)

443. Koestel, A., Computing temperatures and velocities in vertical jets of hot or cold air, *Heating, Piping & Air Conditioning* 26, 6, 143-148, June 1954.

This paper, intended for heating and ventilating engineers, deals analytically with idealized vertical jets of moderately hot or moderately cold air. Equations are derived for evaluating the centerline variation of velocity and the centerline variation of temperature elevation with distance down from an apparent point source. Both equations contain constants to be found by experiment. The equations do not apply in the terminal zone when the heat flows radially outward. Among the simplifying assumptions are: (1) The temperature elevations and velocity profiles are symmetrical and have the shape of an error function curve; (2) the ratio of heat diffusion to momentum diffusion is a function only of the over-all, effective, turbulent Prandtl number; (3) thermal energy is conserved in the axial direction.

The equations are compared with test data reported by Schmidt, Corrsin and Uberoi, and Helander. More experimental work is suggested to justify or refine the equations derived and to verify the constants given for the equations.

S.-M. Yen, USA

444. Ehrich, F. F., and Detra, R. W., Transport of the boundary layer in secondary flow, *J. aero. Sci.* 21, 2, 136-138, Feb. 1954.

Authors make use of the theory of Squire and Winter [AMR 4, Rev. 3672] to calculate the perturbation velocities of the secondary flow in a cascade with nonuniform inlet stream. They obtain the position of a stream filament in every plane normal to the main flow direction along the whole cascade blade passage by means of a step-by-step method. In this way they can compute the distribution of the total pressure loss and the contour of the boundary layer in the exit plane of the cascade. The procedure does not take into account any loss effect within the cascade blade passage. The calculated kinetic energy of the perturbation velocities is relatively small and cannot interpret the whole secondary loss in a cascade. Another possible source of secondary losses might be the high-velocity gradients into the hub wall near the pressure side, which are obtained in the calculation.

N. Scholz, Germany

445. Escande, L., Influence of wake alimentation upon the drag of a plate (in French), "Mémoires sur la mécanique des fluides," *Publ. sci. tech. Min. Air, Paris*, 71-84, 1954.

Using drag of rectangular plate with and without end fins to represent minimum and maximum "alimentation" (of i.e., supply of fluid to) wake, author presents wind-tunnel data illustrating effect of bars across wake at several sections, of perforations of different sizes, shapes, and positions, and of jet baffles at various downstream and upstream locations. Drag coefficients vary between maximum and minimum values, with abrupt downward transitions under intermediate conditions. Paper suffers from lack of precise definitions, particularly of drag coefficient for different geometries; variation of coefficient with increasing velocity for finned plate itself suggests existence of extraneous experimental factors.

H. Rouse, USA

446. Garner, H. C., Methods of approaching an accurate three-dimensional potential solution for a wing, *Aero. Res. Comm. Lond. Rep. Mem.* 2721, 19 pp., Oct. 1948, published 1954.

Paper contains suggestions for attempt at determination of accuracy of various approximate methods (e.g., Weissinger, Falkner, and Jones) of solving linearized three-dimensional flat-wing problem in incompressible flow. Difficulties with planforms having (1) discontinuities in slope of edges and (2) control surfaces, i.e., discontinuities in downwash on the wing, are discussed. An iterative procedure is suggested for obtaining improved solutions for wings with control surfaces, and a new form of expansion of the pressure in double series is suggested for the "Vee" wing; both procedures involve lengthy numerical calculations.

A. E. Bryson, Jr., USA

Compressible Flow, Gas Dynamics

(See also Revs. 463, 468, 474, 479, 484, 490, 503, 508, 510, 511, 512, 516, 517)

447. Frankl, F. I., and Karpovich, E. A., Gas dynamics of thin bodies (translated from Russian by Friedman, M. D.), New York, Interscience Publishers, Inc., 1954, viii + 175 pp. \$5.75.

This interesting book is a translation of a Russian text of 1948

and, as such, gives some idea of the state of linearized theory of compressible fluid flow in Russia at that date. The first chapter commences with a brief historical survey and goes on to solve the linearized wave equation in terms of retarded source and doublet potentials, on which most of the subsequent development is based. The second chapter deals with the flow past bodies of revolution in steady and unsteady motion at subsonic and supersonic speeds. A method for extending the analysis to more general slender bodies is indicated, but in 1948 the authors had evidently failed to discover the simplification that has led to the current treatments of this problem. Steady motions of wings in subsonic and supersonic flow are treated in chap. 3 by methods which are now familiar. The method for finite wings in supersonic flow is ascribed to Mme. Krasilshchikova who, it appears, must share with Evvard the credit for discovering it, for it is evident that the discoveries were practically simultaneous and independent. Chap. 4 contains the theory for wings in unsteady motion and the theory for propellers moving with subsonic forward speed and with either subsonic or supersonic tip speeds. The theory of conical fields in supersonic flow is developed in chap. 5 by Busemann's original method; the extension to homogeneous fields and unsteady motion is also treated briefly.

Had this translation been available soon after 1948, it would have been very valuable to all research workers in the field, and even now it can be read with some profit. But six years have elapsed and techniques have improved considerably in that time, with the result that some of the analysis appears to be rather old-fashioned. However, the analysis is all elementary in the sense that "finite part" techniques, operational methods, etc., are not used, which makes the book very suitable for use as an introduction to the subject, as the translator suggests.

The translator remarks in his preface: "For the most part the translation is literal, with no effort made to impose the translator's style on the authors' intentions." In the reviewer's opinion, the insertion of a few translator's notes pointing out erroneous and incomplete passages and commenting on subsequent developments would have been most valuable, particularly if the book is to be used as an introduction for students. Nevertheless, the book is very readable as it stands, and the translator is to be congratulated on the outcome of his task.

G. N. Ward, England

448. Solomon, G. E., *Transonic flow past cone cylinders*, NACA TN 3213, 56 pp., Sept. 1954.

The results of experiments, performed in the continuous-flow wind tunnel at GALCIT, are presented for transonic flow past cone-cylinder axially symmetric bodies.

Using an interferometer of the Mach-Zehnder type, the local Mach-number contours have been determined in a meridional plane for flows with an attached and detached shock wave. The sonic line location in these flow regimes has been determined by a wave-reflection method; author has experimentally verified the occurrence of smooth shock-free supersonic-to-subsonic compression.

For a 20° and a 25° semi-angle cone, the variation with free-stream Mach number of the shock-wave angle, the surface Mach-number distribution, and the drag coefficient has been investigated. The results for the sonic line location, the shock-wave angle, and the surface Mach number in the region near the cone tip indicate that the flow is conical near the tip of a finite cone, even when the surface Mach number is less than sonic.

The experimental values of the surface Mach number at various values of the free-stream Mach number M_∞ show that the first and the second derivative of the surface Mach number to M_∞ are zero at $M_\infty = 1.00$; using these experimental data, a prediction can be made for the first and the second derivatives of the drag

coefficient to the free-stream Mach number M_∞ at $M_\infty = 1$. The experimental slope of the drag coefficient versus M is in agreement with this prediction.

The investigations on the detachment distance of a shock wave from a finite cone do not agree with the detachment Mach number predicted by conical theory for a semi-infinite cone.

An approximate solution for transonic conical flow has been developed and the agreement with exact conical theory is very satisfying.
E. M. de Jager, Holland

449. Jacobs, W., *Transonic flow past swept and unswept wings between parallel walls*, *Flygtekn. Försöksanst. Medd. Rep.* 55, 34 pp., Feb. 1954.

The purpose of this work is to investigate experimentally the wall interference effects on straight and swept wings between parallel walls at high subsonic speeds as well as transonic and supersonic Mach numbers. The pressure distributions on non-lifting circular arc airfoils were measured to determine the drag of the wings and thus the influence of the walls on the effective sweep angle. Schlieren photographs were taken to determine the influence of the sweep angle and the wall interference on the shock waves as well as on the flow pattern in general. This investigation should be of interest to those confronted with the problem of decreasing the drag losses of turbine blades at high speeds.
J. Persh, USA

450. Kryuchin, A. F., *Flow around a wedge-shaped profile with a detached line of strong discontinuity* (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* 97, 1, 37-40, 1954. (English translation by M. D. Friedman on file with Scientific Translations Division, Library of Congress.)

Problem has been treated previously by Vincenti [AMR 4, Rev. 4530] by means of relaxation technique. Present analytical treatment has, according to reviewer's opinion, little chance of success because of convergence difficulties.

G. Guderley, USA

451. Kryuchin, A. F., *Drag of a rhomboid profile at transonic speeds* (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* 97, 2, 205-208, 1954. (English translation by M. D. Friedman on file with Scientific Translations Division, Library of Congress.)

See preceding review.

452. Yoshihara, H., *On the flow over a wedge in the upper transonic region*, *WADC Tech. Rep.* 53-478, 18 pp., Nov. 1953.

Transonic flow past a diamond wedge with an attached nose shock is analyzed in the hodograph plane where, if the independent variables are scaled in accordance with the von Kármán similarity law, the stream function approximately satisfies the Tricomi equation. The solution in the region between the shock, the nose wedge, and the limiting Mach wave from the shoulder which intersects the bow wave at the sonic point, is found in terms of a set of hypergeometric eigenfunctions, each of which satisfies the boundary conditions on the nose and shoulder. The shock jump conditions call for the expansion of an assigned function in terms of these eigenfunctions. The author determines the first few coefficients by least squares but leaves the question of the completeness of the set open. For the values 1.191, 1.197, and 1.213 of ξ_0 [i.e., of $(M_0^2 - 1)/[(\gamma + 1)\theta_w]^{3/2}$, where M_0 is the free-stream Mach number, $\gamma = c_p/c_v$, and θ_w is the semi-nose angle], the shock conditions are adequately satisfied, but for $\xi_0 = 1.231$ no adequate combination of eigenfunctions could be found. Downstream of the limiting Mach wave the flow is found by the method of characteristics. Pressure distributions, lift, and lift-curve slopes are given, but no experimental results were available

for comparison. A lift maximum when the shock detaches at $\xi_0 = 1.191$ is predicted. A. F. Pillow, Australia

453. Kelly, H. R., The estimation of normal-force, drag, and pitching-moment coefficients for blunt-based bodies of revolution at large angles of attack, *J. aero. Sci.* 21, 8, 549-555, 565, Aug. 1954.

The method developed by H. Julian Allen is subjected to refinements which result in improved predictions for bodies without boat-tailing. Instead of the steady-state cross drag coefficient, the experimental data of Schwabe [*NACA TM* no. 1039] are used to approximate the growth of the viscous cross flow along the body. A boundary-layer correction is applied to the potential theory term and the effect on the cross drag coefficient is also estimated. For supersonic flow, the second-order theory of Van Dyke is used in place of Munk's theory to obtain a more accurate potential flow solution. H. A. Linstone, USA

454. Timman, R., Reciprocity of the lifting surface for an arbitrary unsteady motion (in German), *Z. Flugwiss.* 1, 6, 146-149, Nov. 1953.

Author generalizes the reverse flow theorem for lifting surfaces in nonstationary flow that is due to Flax [AMR 6, Rev. 178]. To simplify the analysis, the linearized wave equation in a space-fixed coordinate system is transformed into a wing-fixed coordinate system by means of the Lorentz equations. The complex Fourier transform is then applied and the generalization follows upon application of Green's theorem. Two examples are computed to show that the new result contains the earlier theorems of Flax and of Heaslet and Spreiter [AMR 6, Rev. 988]. This generalization should prove quite useful in the calculation of the aerodynamic characteristics of wings in certain types of non-steady motion. E. E. Covert, USA

Turbulence, Boundary Layer, etc.

(See also Revs. 444, 508)

455. Baatard, F., A verification of Heisenberg's spectral theory on turbulence (in French), *C. R. Acad. Sci. Paris*, 239, 7, 531-533, Aug. 1954.

The dispersion of a water jet is caused by the internal turbulence of the flow. The angle of dispersion is dependent (beside a number of other factors) on the initial pressure. The dissipation of energy may be calculated by the spectral law of turbulence of Heisenberg and shows that there is proportionality between the tangent of the angle of dispersion and the dissipated energy. This holds good for the wave numbers k between 1 and 6 cm^{-1} . For the higher numbers, the Reynolds number becomes too small and the energy of turbulence is transformed into heat. J. A. Businger, Holland

456. Ogura, Y., Theoretical distribution function of matter emitted from a fixed point, *J. meteor. Soc. of Japan* (II) 32, 1, 22-26, Jan. 1954.

The distribution of matter emitted from a one-dimensional point source is determined by the method of random walk, under the assumption that the phase angles of elementary components of velocity are random and independent of each other. The distribution function is shown to approach the normal form when the time-from-source is sufficiently large and when the velocities are not restricted to a small number of harmonic components. These results are hardly surprising, but would be the more satisfying if accompanied by physical interpretation of the assumptions,

which would clarify the mechanism of dispersion. A valuable feature of the analysis is the expression of the standard deviation in terms of assumed spectral distributions in the low and intermediate wave number range. I. Michelson, USA

457. Corrsin, S., Interpretation of viscous terms in the turbulent energy equation, *J. aero. Sci.* 20, 12, 853-854, Dec. 1953.

458. Kaplun, S., The role of coordinate systems in boundary-layer theory, *ZAMP* 5, 2, 111-135, 1954.

The solution to a given boundary-layer problem depends upon the system of coordinates in which boundary-layer approximations are made. Author defines an "optimal" coordinate system with the property that resulting solutions yield an approximation that is valid both within the boundary layer and in the external flow field. This optimal solution is obtained, by a substitution, from the solution with respect to a conventional coordinate system. It is shown that the flow field as a whole varies with the choice of coordinates, while wall values, such as skin friction, remain unaffected. Basic assumptions are that the flow is steady, two-dimensional, and incompressible. G. M. Low, USA

459. Main-Smith, J. D., Chemical solids as diffusible coating films for visual indications of boundary-layer transition in air and water, *Aero. Res. Council. Lond. Rep. Mem.* 2755, 16 pp., Feb. 1950, published 1954.

The transition point from laminar to turbulent boundary layers in both air and water flow over a surface may be made visible by coating the surface with suitable materials which remain on the surface for a reasonably long time in the laminar boundary layer, but which are rapidly worn off by the turbulent boundary layer. A number of organic coating materials were tested. Factors such as volatility and solubility impose limits on the useful temperature range for each substance and on the time of exposure to flow.

This method of making the boundary-layer transition visible in a short time and at low expense should become an increasingly useful tool to aerodynamic research and naval architecture as a wider variety of coating substances are being examined. This paper constitutes a useful step in that direction.

A. W. Gessner, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 328, 360, 446, 448, 449, 453, 474, 478, 493, 503)

460. Evans, A. J., The zero-lift drag of a slender body of revolution (NACA RM-10 research model) as determined from tests in several wind tunnels and in flight at supersonic speeds, *NACA Rep.* 1160, 13 pp., 1954.

Supersedes article reviewed in AMR 6, Rev. 3542.

461. Hunn, B. A., A note on the evaluation of the supersonic downwash integral, *Aero. Quart.* 5, part 2, 111-118, July 1954.

Note derives integrals (suitable for numerical evaluation) for downwash in plane of symmetry behind flat, subsonic-edged delta wing at incidence and along portion of line—formed by intersection of plane of symmetry and plane of wing—having points the forecones of which completely contain a flat arrowhead wing with subsonic leading and supersonic trailing edges. H. Lomax, USA

462. Küchemann, D., Types of flow on swept wings with special reference to free boundaries and vortex sheets, *J. roy. aero. Soc.* 57, 515, 683-699, Nov. 1953.

This is a discussion of the various types of flow which may occur on thin swept wings when the air stream is not attached to the wing surface everywhere. In particular, the behavior of vortex sheets which arise from such mixed flows is examined.

From author's summary

463. Truckenbrodt, E., Contributions to the extended lifting-line theory (in German), *Z. Flugwiss.* 1, 2, 31-37, July 1953.

The Prandtl lifting-line theory is extended to swept or yawed wings. Generalized expressions are presented and a numerical example is given, indicating the method of computation of the lift and moment distributions. The Prandtl-Glauert rule is used to account for the effects of compressibility.

H. H. Hilton, USA

464. Palme, H. O., Summary of wind tunnel data for high-lift devices on swept wings, *SAAB TN* 16, 18 pp., Apr. 1953.

Author summarizes a collection of wind-tunnel data on the increment in maximum lift achieved by various high-lift devices on airfoil profiles and on finite-span wings. Approach is statistical in nature, but lack of experimental data conditioned to the requirements of statistical analysis make the report of limited usefulness. Practically all of the "design" curves showing the effects of flap span and of wing sweep exhibit scatter of the order of 20% with a large number of experimental data showing even larger deviations. No criticism of the author is herein implied; it merely reflects the fact that very few experimental programs have been conducted on swept wings in which systematic tests were made with the view in mind of isolating the variables affecting the lift increment due to high-lift devices. It is the reviewer's opinion that a more fundamental approach to this problem can be achieved by relying on section data to predict the lift increment due to high-lift devices and using simple sweep theory and appropriate span-loading theory to apply the section data to the prediction of the lift increment on a finite span wing. An empirically derived factor will probably have to be applied to account for deviations from simple sweep theory, but the uncertainty in the magnitude of this empirical factor would be expected to be much less than the uncertainty in maximum lift associated with the reference report.

R. M. Crane, USA

465. Palme, H. O., Maximum lift for landing of swept wing aeroplanes, *SAAB TN* 17, 14 pp., Apr. 1953.

Author attempts to predict lift coefficient and angle of attack for landing of swept-wing airplanes. He concludes that a landing lift coefficient equal to 90% of the maximum lift can be achieved before the airplane becomes uncontrollable due to wing dropping, loss of lateral control, and/or dangerous longitudinal instability. Maximum lift can be determined from the author's *SAAB TN* 15 or 16, and the landing lift coefficient taken as 90% of this value. It is the reviewer's opinion that this report is a dangerous oversimplification of an extremely complex subject. This same criticism can be leveled against the above companion reports. The effects of wing profile, camber, twist, and taper ratio are almost completely ignored. Sweep and aspect ratio are treated indiscriminately in certain of the figures and the intended relationship between the two is never clearly delineated. Perhaps this is clarified by Table I of the report, which was not available to the reviewer. While the report might be of limited usefulness in preliminary design, the limitations of the analysis must be recognized and considerable care should be exercised to insure that im-

portant parameters which are ignored in the report are not overlooked in application of the collected data.

R. M. Crane, USA

466. Schmidt, R., Systematic flight measurements on lateral controls. Parts I, II (in German), *Z. Flugwiss.* 2, 5/6, 113-126, 142-149, May/June 1954.

Results are given of flight measurements of lateral stability coefficients of different fin and rudder arrangements on a twin engine Do-217 aircraft. Measurements were part of an unfinished series of flight experiments on different aircraft commenced in World War II. Part I of paper gives aerodynamic coefficients obtained for two fin and rudder arrangements of different size and shape. Results are compared with wind-tunnel measurements on isolated tail units and on complete aircraft models, and fairly good agreement is obtained. Part II of paper gives measurements of total pressure and flow direction near the twin fins and in the plane of symmetry above the fuselage. Efficiency factors are calculated for the twin-fin arrangement and for a single central fin and rudder for a range of flight conditions.

From author's summary by R. N. Cox, Canada

467. Williams, J. L., Directional stability characteristics of two types of tandem helicopter fuselage models, *NACA TN* 3201, 44 pp., May 1954.

The results of a low-speed wind-tunnel investigation of the directional stability characteristics of an overlap-type fuselage as affected by fuselage and pylon (vertical tail) modifications, of a nonoverlap type fuselage as influenced by spoilers, and vertical-type fuselage as influenced by spoilers and vertical-tail changes are presented in this report. Tuft-grid pictures of the air flow behind the nonoverlap-type fuselage are also presented.

From author's summary

468. Lawrence, H. R., and Flax, A. H., Wing-body interference at subsonic and supersonic speeds—survey and new developments, *J. aero. Sci.* 21, 5, 289-324, 328, May 1954.

Paper presents a critical survey of theoretical methods available for treatment of wing-body interference effects, together with analytical methods for use in design, experimental results, and new developments associated with the authors and their co-workers. Included are: (1) Approximate theory for low-aspect-ratio combinations for which wings have straight trailing edges; (2) semiempirical design methods for predicting subsonic characteristics of low-aspect-ratio combinations; (3) variational methods used to predict characteristics of high-aspect-ratio combinations according to lifting-line theory; (4) supersonic experimental results and analysis; (5) approximate methods for prediction of body loading in supersonic flow; and (6) general integral relations in linearized theory of wing-body interference.

The introduction provides a thorough survey of the literature associated with the subject, and a valuable list of references is included.

M. A. Heaslet, USA

469. Sternfield, L., A vector method approach to the analysis of the dynamic lateral stability of aircraft, *J. aero. Sci.* 21, 4, 251-256, Apr. 1954.

A vector method of analysis of dynamic stability problems is described. Vectors are used to represent the various terms in differential equations and employed in two-degree-of-freedom problems to solve for phase angles, amplitude ratios, and damping angles, provided that the frequency of the oscillation is known. A vector machine is described that can be used for frequency response. Application is made to Dutch-roll oscillations.

R. Oldenburger, USA

470. Smith, A. G., and White, H. G., A review of porpoising instability of seaplanes, *Aero. Res. Coun. Lond. Rep. Mem.* 2852, 41 pp., Feb. 1944, published 1954.

471. Walker, K., Jr., Some aerodynamic characteristics of wide-delta cruciform wings with Canard-Delta or trailing-edge control surfaces, *Douglas Aircr. Co. Rep.* SM-14976, 58 pp., Nov. 1953.

Linearized-theory values of loading on triangular wings with supersonic leading edges and constant chord flaps are used to evaluate lift, moment, and center of pressure for cruciform wings having differentially deflected flaps on the horizontal wing and having the vertical wing aligned with the free stream.

G. Nitzberg, USA

472. Blahó, M., Drag of trains in tube tunnels, *Acta Techn. Hung. Budapest* 8, 3/4, 185-206, 1954.

The drag of a scale model train in a railroad tunnel has been investigated for the cases of smooth and ribbed tunnel walls, of several train-to-tunnel cross-section area ratios, and of several train lengths. The air flow was simulated by an exhaust fan drawing air into the tunnel and measurements taken of drag and pressure distribution. The pressure distribution is shown to depend mainly on the area constriction of the tunnel. The drag coefficient is shown to increase nonlinearly with the number of cars in the train, to increase with roughness of the tunnel wall, and to increase rapidly with tunnel consideration. Pipe friction coefficients for the open annular area between train and tunnel wall and the pressure drops are calculated to obtain comparative values of the drag. A calculation of wake velocity is also carried out.

H. M. Spivack, USA

473. Smith, A. G., Wright, D. F., and Owen, T. B., Towing-tank tests on a large six-engine flying boat seaplane, to specification 10/46 (Princess), II. Porpoising stability, spray and air drag tests, with improved step fairing, afterbody design and aerodynamic modifications, *Aero. Res. Coun. Lond. Rep. Mem.* 2834, 32 pp., Nov. 1950, published 1954.

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 454, 466)

474. Goland, M., and Luke, Y. L., An exact solution for two-dimensional linear panel flutter at supersonic speeds, *J. aero. Sci.* 21, 4, 275-276, Apr. 1954.

Authors consider a rectangular panel of great width and of length $2b$ in stream direction, being supported on rigid beams along the two wide edges (i.e., the leading and trailing edges). A supersonic stream with undisturbed velocity V and density ρ passes over one side of the panel, directed normally to the supported edges. The panel is of uniform thickness and composition. Two extreme cases are discussed, in which the panel is considered either as a pure membrane or as plate in pure bending. The eigenvalues of the pure elastic problems are easily found. For the aerodynamic force $P(x)$ along the stream direction, a derivation by Miles is used. The resulting integrodifferential equation of the aeroelastic problem in the pure bending case is solved by straightforward Laplace transform technique. However, the solution gives the panel mode shape in a rather involved form as a function of Mach number, density and $k = \omega b/V$. Flutter will result when eigenvalues k satisfy the boundary conditions of the panel shape at the leading and trailing edges. Numerical calculation of each specific case is needed in order to arrive at any general conclusions. It is shown, though, that there

must exist a lower and upper limit of Mach numbers for the panel flutter region.

J. R. Schnittger, Sweden

475. Johnson, W. H., Vibration and flutter of aircraft aeriels, *Aero. Res. Coun. Lond. curr. Pap.* 146, 14 pp., Dec. 1953, published in 1954.

Fatigue failures of blade and whip aeriels are attributed to the high response of their first flexure modes to mechanical and aerodynamic excitation. Tests performed showed that icing of the aeriels could sufficiently affect their contour to cause a single-degree-of-freedom flexure stall flutter. Introduction of nonlinear damping in the aerial mounting successfully prevented further fatigue failures.

W. Targoff, USA

476. Templeton, H., The technique of flutter calculations, *Aero. Res. Coun. Lond. curr. Pap.* 172, 62 pp., 3 figs., Apr. 1953, published 1954.

Report describes the basic principles on which theoretical flutter analyses are made and illustrates them by some simple applications. The techniques employed are typical of those in current use in England. Three appendixes give the two-dimensional aerodynamic derivatives for a wing-aileron-tab system, computational details of typical forms of solution, and an illustration of the use of resonance test modes in flutter calculations.

From author's summary

477. Shioiri, J., Flutter in cascading blades. I. General theory and stability of pure bending flutter, *Gov. mech. Lab., Tokyo Bull.* no. 3, 13 pp., 1954.

Bulletin deals with free, single-degree-of-freedom vibration of cascades coupled by aerodynamic forces only. A stability discriminant for the m th mode of vibration of the system is obtained as a function of the m th mode frequency and the phase difference α_m between neighboring blades. The discriminant also involves aerodynamic influence factors which express the inter-blade interference but are undetermined at this point.

The special case of bending vibration at the natural frequency of the blades is considered in detail, using an approximate aerodynamic model to evaluate the influence factors. In this model, a central airfoil is considered together with four neighboring airfoils represented by concentrated vortexes, and two-dimensional thin-airfoil results are taken from Sears [*J. aero. Sci.* 8, 3, 104-108, Jan. 1941]. The expression for the lift contains, in addition to single-airfoil terms, an additional term due to flow component parallel to the central blade chord induced by neighboring blades. Reviewer believes this term must be of higher order if the assumptions of thin-airfoil theory are to apply. Numerical examples for this case indicate this type of vibration can be self-sustaining. Author believes that, because of the greatly simplified aerodynamic model, the method is probably inadequate for calculating critical velocity or critical reduced frequency.

R. W. Detra, USA

478. Ijff, J., Influence of compressibility on the calculated flexure-torsion flutter speed of a family of rectangular cantilever wings, *Nat. LuchtLab. Amsterdam Rap.* F. 118, 10 pp., 1953.

The flutter speed of 27 wings with different positions of elastic and inertia axes and different values of the relative density parameter has been calculated for three values of the Mach number.

It has been found that the influence of compressibility can be favorable as well as unfavorable, depending upon the case investigated. All results are presented in a number of diagrams, which also show the influence of the other parameters on the flutter speed.

From author's summary

479. Li, T. Y., and Stewart, H. J., On an integral equation in the supersonic oscillating wing theory, *J. aero. Sci.* 20, 10, 724-726, Oct. 1953.

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 392, 421, 477, 497, 520, 535)

480. Berry, C. H., *Flow and fan*, New York, The Industrial Press, 1954, vi + 226 pp. \$4.

Professor Berry's new book, addressed to the student as well as the practicing ventilating engineer, merits special attention because of the author's effectiveness in skillfully relating pertinent basic principles of fluid dynamics to the highly empirical practice of ventilating engineering. While presenting problems of fans and of flow in ducts in a simple rational fashion, the author, well aware of the practical possibilities of translating theory into professional practice, recognizes certain limits. Interestingly, he sees these limits not so much in lack of physical intuition of his readers as in their unfamiliarity with mathematical analysis.

Contributions of a research nature are the author's investigations of problems of control and regulation of fans for variable duty by speed change, damper, and vane adjustment and of matching of one or more fans to ventilating duct systems. The stability of fans is analyzed on the basis of the steady-flow characteristics of both fan and duct system. Here it would appear desirable that reference be made to the dynamic characteristics and to mutual dynamic interaction of both fan and system, which reference would serve as an introduction to recent research on fan instability. Analytical treatment of dynamic stability, however, would be beyond the scope of the book.

J. R. Weske, USA

481. Klann, A. R., Economical turbine design for marginal hydroelectric plants—How to make obsolete or uneconomical plants profitable, *Mech. Engrg., N. Y.* 76, 11, 905-908, Nov. 1954.

482. Darling, R. F., Fuel systems and controls for marine gas turbines, *Proc. Instn. mech. Engrs.* 168, 5, 159-165, 1954.

483. Forsling, B. E. G., Main propulsion gas-turbine set for oil tanker, *Proc. Instn. mech. Engrs.* 168, 5, 166-175, 4 plates, 1954.

484. Morghen, K., and Rothe, K., Calculation of the flow in axial compressors (in German), *Z. Flugwiss.* 2, 6, 149-154, June 1954.

Author develops method for calculating the effect of losses on the flow through axial compressor blading. Simultaneous equations are derived from which the axial and rotational components of the absolute gas velocity, blade angles, temperatures, and pressures can be determined graphically. Calculation gives these quantities at any cross section and radius in terms of the inlet conditions and the blade geometry. Assumptions made are that flow occurs over coaxial conical surfaces, radial equilibrium exists, and efficiency does not depend on radius. Effect of losses is introduced by the temperature-rise efficiency relating actual and theoretical temperature rise. Working equations are given for rotor, stator, and inlet guide row. In latter, flow is assumed to be over coaxial cylindrical instead of conical surfaces.

As an example, variation of head, blade angle, and rotational component c_u with radius at the discharge section are determined for a rotor with a 0.6 hub ratio and a prescribed variation of inlet conditions. Calculation is made for 90 and 100% efficiencies. Results indicate that variation of quantities with radius is less for

90% case. Author notes that decrease is greater in later stages.

Consistent with assumptions, c_u is shown to be limited to a maximum value at the root equal to blade velocity u at root. For values of c_u greater than u at the root, the graphical solution for c_u becomes discontinuous at the radius where c_u equals u .

Equations are given, based on work of Wenig and Eckert, for efficiency in terms of the design parameters.

Reviewer notes a number of misprints in the equations.

H. E. Brandmaier, USA

485. Lyn, W. T., An experimental investigation into the effect of fuel addition to intake air on the performance of a compression-ignition engine, *Proc. Instn. mech. Engrs.* 168, 9, 265-278, 1954.

The investigation arose from a program of research into the means of reducing combustion noise and engine roughness in a compression-ignition engine.

From author's summary

486. Foster, D. V., The performance of the 108 compressor fitted with low stagger free vortex blading, *Aero. Res. Coun. Lond. curr. Pap.* 144, 36 pp., June 1952, published 1954.

A 3-stage, axial-flow compressor is described along with its equipment. The installation is designed for proposed secondary flow studies. Preliminary tests at 900, 700, and 500 rpm are reported with the aid of 13 graphs, and predicted performance is compared with experiment. Data on surge and on the axial velocity profile are discussed. The report does not go far into the theoretical aspects of the test results or the design. It does give an orderly account of the specific machine and its major characteristics. The tests were limited to a maximum Mach number of 0.23 and a maximum Reynolds number of 3×10^6 at the highest speed.

R. A. Burton, USA

487. Jaburek, F., Calculation of stress and strain in radially bladed impellers (in German), *Öst. Ing.-Arch.* 7, 3, 214-230, 1953.

A method is presented for calculating average and bending rotating disk displacements, strains, and stresses in several types of centrifugal impellers. Differential equations are derived, intending that they be solved by methods of finite differences. Illustrative designs and resulting stresses are discussed but details of numerical techniques are not given. Complexity of problem requires abandonment of classical theory of elasticity, and simplifying assumptions are made of type ordinarily used in elementary theory of structures. Such assumptions lead to minor discrepancies; for example, Fig. 6 shows a nonzero radial stress at tip of vane.

Reviewers believe paper is an important and useful aid for designers of rotating disks, particularly with respect to the estimation of bending stresses. Equations were found to contain some typographical errors.

A. G. Holms and H. G. Linke, USA

Flow and Flight Test Techniques

(See also Revs. 460, 464, 466, 472, 473, 505)

488. Frank, W. E., and Gibson, R. J., A new pressure-sensing instrument, *J. Franklin Inst.* 258, 1, 21-30, July 1954.

A new pressure-sensing instrument involving capacity changes has been developed. Arrays consisting of a number of these "Filpips" (Franklin Institute Laboratories Pressure Indicating Patch) have been constructed and connected to simple electronic measuring instrumentation. Generally, reproducibility within 10% is obtainable.

From authors' summary

489. van der Walle, F., A possible method for obtaining high Mach numbers using compressed air supplies of relative low pressures, *J. roy. aero. Soc.* 58, 523, 510-512, July 1954.

490. Baldwin, B. S., Jr., Turner, J. B., and Knechtel, E. D., Wall interference in wind tunnels with slotted and porous boundaries at subsonic speeds, *NACA TN* 3176, 42 pp., May 1954.

Flow in free air far from the "tested" model is approximated by that of a doublet or a horseshoe vortex of infinitesimal span. Introduction of restraining boundaries due to two-dimensional and circular tunnels induces an additional potential flow which brings about additive changes in velocity at the model location, the so-called blockage and upwash corrections, when the linearized compressible equations are used. Computation of the induced flow by standard Fourier transform techniques. The new element of interest is the treatment of the approximate boundary conditions at slotted and porous walls. Since this aspect has been only recently declassified, one should add to the authors' references the following, where similar or identical results have been reached: Meader, P. F., *Tech. Rep.* WT-11, Brown Univ., Dir. of Engng., Sept. 1953; Davis, D. D., Jr., and Moore, D., *NACA RM* L53E07b, June 1953; also work by Guderley, G., at Wright Air Development Center, Dayton, Ohio. M. V. Morkovin, USA

491. Ormerod, A. O., An investigation of the disturbances caused by a reflection plate in the working-section of a supersonic wind tunnel, *Aero. Res. Council. Lond. Rep. Mem.* 2799, 16 pp., Nov. 1950, published 1954.

An investigation has been made of the disturbances caused by a reflection plate, mounted clear of the boundary layer in a supersonic tunnel. Static traverses were made, mainly at a Mach number of 1.4 above four reflection plates having different plan-forms, with various conditions in the passage between the plate and the tunnel wall.

In the region above the plate two main disturbances were found; there was a small disturbance from the leading edge and a disturbance further downstream which had originated beneath the plate. Between the two there was a region of approximately constant pressure in which a model could be located. The forward disturbance seemed unavoidable. Increasing the area of the passage beneath the plate by a recess in the tunnel wall was the most effective way of moving back and reducing the magnitude of the disturbance at the rear. With the best arrangement, at a Mach number of 1.4, it was found possible to obtain a region of approximately constant pressure, extending downstream from the apex of the plate for a distance of about 0.66 times the height of the tunnel.

A plate spanning the tunnel was found to be unsuitable because of disturbances originating at the extremities of the leading edge in or near the tunnel boundary layer.

From author's summary

492. Stewart, W., Flight tests on swinging during take-off on a single-engined fighter-bomber (Typhoon Ib), *Aero. Res. Council. Lond. Rep. Mem.* 2660, 29 pp., Apr. 1948, published 1953.

Flight tests have been carried out on a Typhoon aircraft to compare the values of the aerodynamic side forces and yawing moments, during take-off, with the wind-tunnel measurements, and to compare various methods of estimating the rudder angles required to trim during a take-off run.

The results show very good agreement with the wind-tunnel tests. As runs have been done under various crosswind conditions on the aerodrome (i.e., different angles of sideslip), the order of each of the aerodynamic components was verified.

A method of evaluating the rudder angles required to trim is suggested; namely, solving the side-force and yawing-moment equations simultaneously, using the wind-tunnel measurements for the aerodynamic components and introducing the side force from the undercarriage, in terms of the crab angle of the wheels. In the yawing-moment equation, the second-order differential inertia term is neglected as the changes of angle in the theoretical calculations (representing a straight take-off run) are very small. The effect of the tail wheel has been disregarded, as it is only in operation during the initial stages of the run.

Due to considerable overcorrection by the pilot, it is desirable to design for a rudder range at least 20% in excess of that required to trim. From author's summary

493. Zalovcik, J. A., Lina, L. J., and Trant, J. P., Jr., A method of calibrating airspeed installations on airplanes at transonic and supersonic speeds by the use of accelerometer and attitude-angle measurements, *NACA Rep.* 1145, 13 pp., 1953.

Supersedes articles reviewed in AMR 4, Rev. 1326; 5, Rev. 3543.

494. Grasshoff, H., Measurement techniques for forces during collisions and similar phenomena (in German), *Bautechnik* 30, 5, 137-140, May 1953.

Author describes briefly the following methods to determine space-, velocity-, or acceleration-time curves in the case of the pile-driving phenomenon:

(1) Feldkeller and Keul use the magnetostriction effect to measure the acceleration; an application of the method relates to the penetration of cones into sand. (2) Majer has developed an accelerometer based on the induction effect; Rühle used the instrument to measure the penetration of slow projectiles into different materials. (3) Cummings, Casagrande, and Hoffmann made a mechanical registration of the movement of a driven pile on a rotating drum. (4) Author proposes the use of a high-speed camera with a tele-object glass. H. Schardin, Germany

495. Vitale, A. J., Press, H., and Shufflebarger, C. C., An investigation of the use of rocket-powered models for gust-load studies with an application to a tailless swept-wing model at transonic speeds, *NACA TN* 3161, 36 pp., June 1954.

A technique for rocket-powered model testing in rough air using a survey airplane is evolved. The results are in agreement with theoretical calculations based on power-spectral method of harmonic analysis. From authors' summary by A. Petroff, USA

Thermodynamics

(See also Rev. 403)

496. Hirschfelder, J. O., Curtiss, C. F., and Byrd, R. B., *Molecular theory of gases and liquids*, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, xxvi + 1219 pp. \$20.

This compendium brings together in one volume most of the significant advances of the past 20 years in the area of theoretical physical chemistry of fluids. Much of this work has been developed and coordinated by the senior author and his associates at the University of Wisconsin Naval Research Laboratory. The treatment is comprehensive in coverage, detail, and documentation. It can serve as a primary reference for work at any level dependent on this area of information.

Following an introduction reviewing the fundamentals of classical mechanics, kinetic theory, and quantum mechanics, the first

of three major parts covers the field of properties of equilibrium systems. The first chapter in part I presents statistical mechanics and its application to the thermodynamics of fluid systems. The following chapter develops the equation of state for low and moderate density gases, developing primarily the virial equation of state for polar and nonpolar gases from intermolecular potentials. The next chapter considers equations of state for dense gases, reviewing various empirical correlations and theoretical models providing useful equations.

Chap. 5 discusses vapor-liquid equilibria and critical phenomena. The last chapter of part I introduces quantum theory considerations to the equations of state with particular reference to the partition function and virial coefficients at low temperatures and the intermolecular potentials and equations of state of gases of extremely low molecular weight.

Part II is concerned with nonequilibrium properties and behavior of fluid thermodynamic systems. Chap. 7 develops the kinetic theory and statistical mechanics for systems in the neighborhood of equilibrium states. This basic theory is applied in chap. 8 to describe transport phenomena for low density gases. The several transport coefficients are formulated in terms of the intermolecular potential. A similar development is given in chap. 9 for dense gases and liquids, and chap. 10 introduces the effects of quantum theory. As an application on nonequilibrium properties, part II concludes in chap. 11 with a review of the several equations of diffusion, momentum, and energy for the most general class of fluid systems. Some cases of practical concern such as flame propagation, shock waves, detonation, and propellant gas flow are considered.

The final part III develops the general theory of intermolecular forces on which the first part depends. Chap. 12 provides the foundations in electromagnetic theory which are systematically applied in chap. 13 to formulate the several types of intermolecular forces. The final chapter considers quantum mechanical effects on intermolecular forces.

This treatise is too extensive to assess briefly. The significance to the authors is indicated by their plan to issue a series of addenda and corrigenda to keep up to date with current developments. Two of this series have already appeared.

N. A. Hall, USA

497. Kornitsky, S. Y., Rubinshtain, Y. M., et al., *General thermodynamics* [Obshtshaia teplotekhnika], 2nd ed., Moscow-Leningrad, Gosenergoisdat, 1952, 520 pp. \$2.20.

A textbook for engineers divided into three main parts: Theoretical fundamentals; Steam cycles; Gas cycles. First part considers ideal gases, thermodynamic laws and their application, and heat transfer. Second part deals with boilers, steam engines and turbines, complete power stations and their operating requirements. Third part is devoted to liquid fuels, I. C. engines, gas turbines, and C. I.-engined power stations. This is a sound, clearly written conventional text dealing with the theory and application of thermodynamics elucidated by worked-out examples and details of representative Russian designs of boilers, stationary and ship stem engines, turbines of 2500, 25,000 and 50,000 Kw, condensers, petrol and C. I. engines. However, the main interest is in the data on gas turbines. J. L. Koffman, England

498. Ross, J., and Kirkwood, J. G., The statistical-mechanical theory of transport processes. VIII. Quantum theory of transport in gases, *J. chem. Phys.* 22, 6, 1094-1103, June 1954.

The quantum-mechanical Boltzmann equation determining the molecular phase space distribution for nonuniform gases was derived for the first time from the principles of quantum mechanics by Mori and Ono [*Progr. theor. Phys.* 8, 327, 1952].

Derivation involves phase- and time-averaging processes. Authors present an alternative method of averaging which, they claim, is better suited for a (future) theory of improved accuracy. R. Eisenschitz, England

499. Brout, R., Thermal relaxation in gases, *J. chem. Phys.* 22, 9, 1500-1502, Sept. 1954.

The solution of the linearized equations appropriate for sound dispersion is presented. The limiting cases as the sound frequency becomes large or small are examined. The two-state gas is exhibited as a special case and shown equivalent to previous work in the field when the appropriate assumptions are made.

From author's summary

500. Landsberg, R., and Seibald, S., Some thermodynamic properties of Freon-22, *Bull. Res. Council. Israel* 3, 4, 414-416, Mar. 1954.

501. Snider, R. F., and Curtiss, C. F., The effects of concentration dependence of diffusion coefficients, *Univ. Wisc. Nav. Res. Lab. Rep.* OOR-9, 28 pp., Feb. 1954.

The effect of the small concentration dependence of gaseous diffusion coefficients on the solution of the diffusion equations is considered. A method is developed for taking this effect into account in the measurement of diffusion coefficients.

From authors' summary

502. Hansen, C. F., Note on the Prandtl number for dissociated air, *J. aero. Sci.* 20, 11, 789-790, Nov. 1953.

503. Handbook of supersonic aerodynamics, *Bureau of Ordnance, Navord Rep.* 1488 (vol. 5), 234 pp., Aug. 1953; Supt. Doc., U. S. Gov. Ptg., Office, Washington.

Volume 5, section 15 of the Handbook entitled "Properties of Gases," just published by Bureau of Ordnance, contains in tabulated form the thermodynamic and the transport properties of air.

Needless to say that this information, gathered from the best references and authoritatively presented, is indispensable for an aerodynamicist working with moving air at various speeds and temperatures. A. N. Petroff, USA

Heat and Mass Transfer

(See also Revs. 400, 426, 443, 480, 498, 500)

504. Powell, R. L., and Blanpied, W. A., Thermal conductivity of metals and alloys at low temperatures. A review of the literature, *Nat. Bur. Stands. Circ.* 556, 68 pp., Sept. 1954.

An extensive compilation is given of the measured values of thermal conductivity for metals and alloys from room temperature down to approximately 0 K. The more extensive and important data are plotted in 48 graphs. The tables and graphs for the metallic elements and alloys are essentially complete for literature reference from 1900 to early 1954. For comparison, several graphs and tables are given for some representative dielectrics.

From authors' summary

505. Vernotte, P., The role of pure conduction in the phenomenon of total heat convection. Application to hot-wire anemometry (in French), "Mémoires sur la mécanique des fluides," *Publ. sci. tech. Min. Air, Paris*, 407-412, 1954.

Author shows that when hot-wire-anemometer operation borders or penetrates the Oseen flow regime ($Re \approx 1$), the average heat transfer cannot always be considered plane two-dimensional

even though the length-to-diameter ratio of the wire is large. Three-dimensional diffusion accounts for 20% of the total heat lost to the fluid in the specific example considered ($V = 10$ m/s, $L = 1$ cm, $d = 0.0005$ cm) and reduces the effective exponent of the heat-loss vs. velocity calibration curve from King's value of $1/2$ to a value of $2/5$.

A more comprehensive account of the same phenomenon has been published by Cole, J., and Roshko, A., "Heat transfer from wires at Reynolds numbers in the Oseen range," 1954 Proceedings of Heat Transfer and Fluid Mechanics Institute, Berkeley, Calif. H. A. Stine, USA

506. Korobkin, I., Discussion of local heat-transfer coefficients for spheres and cylinders, ASME Fall Meet., Milwaukee, Wis., Sept. 1954. Pap. 54-F-18, 5 pp.

An attempt is made to resolve a discrepancy between recent investigations and earlier studies in results for spheres. The context is limited to a discussion of the work of other investigators.

R. J. Mindak, USA

507. Batchelor, G. K., Heat convection and buoyancy effects in fluids, Quart. J. roy. meteor. Soc. 80, 345, 339-358, 1 plate, July 1954.

Largely a review of the subject as developed, using dimensional analysis and the assumption of similarity. Laminar and turbulent flows produced in a uniform fluid by maintained point and line sources are discussed. Author then derives a similarity solution for a stratified ambient fluid which applies only to an unstable atmosphere and shows that no source is then required to produce a plume. He next considers the effect of varying the density of the lighter fluid and discusses qualitatively the effects of miscibility and friction. His conclusion that the ambient fluid should be affected least when the density difference is large is borne out experimentally. Consideration is given to convection from a plane surface and attention is drawn to observations of columnar convection at Rayleigh numbers below those required for cellular convection. Preliminary details of experiments on forced convection are given.

Fluid dynamicists will find here an authoritative review and some interesting ideas. Meteorologists looking for detailed discussion of their particular problem of cumulus convection will probably be disappointed but grateful to Dr. Batchelor for putting this problem in a wider perspective.

R. P. Pearce, Scotland

508. Levy, S., Effect of large temperature changes (including viscous heating) upon laminar boundary layers with variable free-stream velocity, J. aero. Sci. 21, 7, 459-474, July 1954.

Paper presents solutions of the laminar boundary-layer equations in a compressible fluid when the main stream Mach number varies like a power of s , where s is proportional to the integral of the main stream velocity taken along the surface. The wall temperature and the product of viscosity and density are assumed constant.

The boundary-layer equations are converted to ordinary differential equations by means of Illingworth's transformation, and numerical solutions obtained on a differential analyzer are given for the following cases: (a) Mach number small, so that viscous dissipation can be neglected, Prandtl number 0.7 and 1.0; (b) arbitrary Mach number, with dissipation taken into account, Prandtl number of unity. In addition, an approximate method of solution for very large Mach number is given, and numerical results presented for a Prandtl number of 0.7. The paper also includes approximate solutions based on the momentum (integral) equation of the boundary layer.

The work is a useful contribution to the theory of the compressible laminar boundary layer; the exact solutions are particularly valuable.

Reviewer believes that there might be some misunderstanding about the use of the term "suction velocity." Numerical solutions for a porous surface are given, and wording of the paper suggests that they apply to a boundary layer with suction; in fact, it appears that the velocity normal to the surface is positive, corresponding to "blowing."

P. R. Owen, England

509. Stahl, C. R., The mechanical design of liquid metal-cooled nuclear reactors, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54-SA-60, 8 pp.

A very brief general summary of unusual mechanical design problems encountered in nuclear reactors of the Submarine Intermediate Reactor type. Discussion includes restraints imposed by nuclear requirements, problems arising from heat generation which varies with space and time, thermal stresses, and mechanisms problems. Reviewer believes experienced nuclear engineers will find little that is new in this paper, but feels it will be of interest to persons entering the field of reactor design.

R. L. Mela, USA

510. Pai, S. I., On the stability of a vortex sheet in an inviscid compressible fluid, J. aero. sci. 21, 5, 325-328, May 1954.

In this note, one studies the stability of a vortex sheet and of an ideal jet in an inviscid compressible fluid with respect to two-dimensional small disturbances. Assuming that the flows on both sides of the vortex sheet are potential flows, the vorticity remains concentrated in the sheet, which at the starting time of the disturbance is supposed to be situated along a straight line (x -axis). The differential equation for the disturbance velocity potential—as is usual in this theory—is solved by supposing an exponential wave to travel with complex phase velocity along the x -axis. This leads to the most simple linear second-order differential equation for the disturbance amplitude function. Substituting its general solution into the boundary conditions for one of the three problems—(1) vortex sheet between solid walls, (2) two-dimensional jet with antisymmetrical and (3) with symmetrical disturbances—easily leads to the corresponding eigenvalue equations.

The study of these equations for infinite domains (wall distance tending to infinity) shows that only for supersonic neutral disturbances with respect to the free stream is there a continuous spectrum of eigenvalues in all three problems. For all other disturbances (including supersonic damped or self-excited disturbances) the eigenvalues are discrete. For a vortex sheet without the influence of a solid wall a new simple criterion for the stability is given and the significance of the supersonic disturbances is discussed.

H. Behrbohm, Sweden

511. Welandar, P., On the temperature jump in a rarefied gas, Ark. Fysik 7, 6, 507-553, 1954.

An approximate solution to the Boltzman equation is obtained in the vicinity of a solid plane boundary for the case of heat conduction. An expression is derived for the temperature jump which differs from the classical result in that the term $(2 - \alpha)/\alpha$ is replaced by $(2 - 0.827\alpha)/\alpha$, where α is the thermal accommodation coefficient. Partial results are also obtained for the velocity slip.

S. A. Schaaf, USA

512. Welandar, P., Heat conduction in a rarefied gas: the cylindrically symmetrical case, Ark. Fysik 7, 6, 555-564, 1954.

The method developed in the preceding review is applied to the cylindrically symmetric case and, in particular, to hot-wire vacuum gage considerations.

S. A. Schaaf, USA

513. Yhland, C.-H., Application of the similarity theory on radiation in furnaces, *Trans. Chalmers Univ. Technol.* no. 135, 31 pp., 1953; *Acta Polyt.* no. 141, 1954.

Author derives from basic principles the steady-state energy equation, in integrodifferential form, for the combustion gases and or the furnace wall. From the inspection of coefficients he then obtains a number of nondimensional parameters, involving such quantities as the ratio of the emissive power of the wall and the gas, or the ratio of the gas emissive power to the heat liberated by combustion per unit volume times some characteristic length of the furnace. In the opinion of this reviewer the paper is inconclusive.

A. K. Oppenheim, USA

514. Lönnqvist, O., Calculating effective radiation with due regard to its diffuse nature, *Ark. Geofys.* 1, 5/6, 441-451, 1953.

An extension of work previously reported by the author in which a long wave radiation formula was developed, giving consideration to upper air conditions as well as surface conditions. The author points out that the formula has certain advantages over the radiation diagrams of Elsasser and others. The original formula treated the downward radiation from the atmosphere as being purely vertical. In this paper, the formula has been corrected to account for the diffuse nature of the atmospheric radiation.

The formula gives the effective long wave radiation to a cloudless sky in terms of the temperature at the surface, the absolute humidity at the surface, the mean temperature lapse-rate up to 2 km, and the humidity factor, which is an integral involving the absolute humidity as a function of height. This latter factor is closely related to the amount of precipitable water in the vertical column of the atmosphere.

The diffuse nature of the radiation may be accounted for, to some extent, by changing the coefficients of absorption of water vapor by a certain ratio, called the diffusing factor. In this paper, the author shows that no constant factor of general applicability may be given, but that a value of 1.65 appears to be a good approximation.

D. W. Pritchard, USA

515. Bäckström, M., The theory of the evaporator working with diffusion, *Kyltekn. Tidskr.* no. 2, 22-26, Apr. 1954.

Paper concerns the evaporation process occurring in a mixture of ammonia and hydrogen gas, such as is found in absorption refrigeration machines. Author illustrates the combined use of two diagrams, both having ammonia concentration as abscissa, and with ordinates of enthalpy of the gas mixture and partial pressure of ammonia. The calculation of processes such as parallel and counterflow evaporators is illustrated. The method can also be utilized to study evaporation in cooling towers employing water and air mixtures.

R. Siegel, USA

516. Koel, J. C., Calculation of the resistance in boiler pipes with forced circulation (in Dutch), *Ingenieur* 66, 13, W.19-W.23, Mar. 1954.

Formulas are developed for calculation of pressure drop in tubes in which evaporation occurs. Heat transfer to the tubes is according to a combination of linear functions of the tube length L . It is supposed that mist flow occurs in the tubes. The resistance coefficient λ for mixed pipe flow, depending on many factors, is discussed. Theory is applied to the stability problem of parallel evaporator tubes of steam boilers. Stabilizing influence of nozzles can be calculated.

J. G. Slotboom, Holland

517. Koel, J. C., The capacity of condensate return systems (in Dutch), *Ingenieur* 66, 15, W.27-W.31, Apr. 1954.

Formulas for calculation of capacity of pipelines and orifices

in condensate return systems are developed. Critical pressure ratio and retardation of evaporation in connection with steam traps are discussed. Results of theory are compared with measurements.

J. G. Slotboom, Holland

Combustion

(See Revs. 421, 482, 485, 513, 520)

Acoustics

(See also Rev. 485)

518. Mandel, H., Sound velocities and elastic constants of heterogeneous substances (in German), *Acustica* 4, 2, 333-340, 1954.

Paper is an abstract of a thesis of the author ["A contribution to the problem of the sound velocity in solid bodies"] submitted to the University of Cologne, Germany. Here author deals especially with the determination of sound velocities and elastic constants of heterogeneous substances. The sound velocity is measured in specially prepared blocks with fixed dimensions and consisting of mixtures of carbonyl-iron powder and Trolitul III (Polysticool with $\rho = 1.06 \text{ g/cm}^3$). The velocity of the propagation of longitudinal and transverse waves is measured by a pulse method, using ultrasonic equipment as used for the nondestructive testing of materials. By comparing the time of travel of a pulse in the test block and in a water column, and using the exactly known velocity of sound in water, the velocity of sound in heterogeneous substances of varying composition is determined. The elastic constants of the heterogeneous substances are derived with the well-known formulas from the sound velocities.

The results of the measurements are given in a series of curves, which show the influence of the increase of the concentration by volume of the carbonyl-iron powder on the sound velocities and the elastic constants. Assuming the heterogeneous substance as the model of a suspension and using existing theories does not yield a formula which correlates with the results of the measurements. Therefore a simplified model for a heterogeneous substance is used to derive a formula which correlates well with the experimental results. It was found that the formula can also be used for porous bodies with a good sound conductivity. As the wave length compared with the average particle size was rather large (at 2.2 mc about 1 mm to 10^{-3} mm), experiments were made with iron-spheres of 0.5, 1, and 2-mm diam in Trolitul III, and with frequencies from 1-5.5 mc. Extremely strong scattering of the sound waves occurred and measurements were only possible up to a concentration of 5-8% by volume. An explanation of this phenomenon is given.

Further experiments were carried out with heterogeneous substances, consisting of components with sound velocities of the same magnitude. Various mixtures of Trolitul III and Araldit were made. As the simplified model for the carbonyl-iron Trolitul mixture cannot be used, a formula is derived with the aid of existing theories and the results of the experiments, which has proved to be very satisfactory.

Experiments with alloys, having over a large range a heterogeneous structure, for which the Trolitul-Araldit mixture can serve as a model, show a good correlation with the results obtained with the Trolitul-Araldit mixture. An example is given for the system lead-tin which consists of from 4-100 atomic per cent tin only of $(\alpha + \beta)$. Calculated and measured data correlate very well. Alloys having a homogeneous structure of only one phase cannot be considered as a heterogeneous substance. Experiments with the system copper-zinc show that measurements are very

difficult in this case, because of the rather narrow regions in which the to-some-extent-complicated equilibrium diagram shows a heterogeneous structure.

The results of the experiments are promising in so far as they seem to offer a possibility of deriving formulas to calculate sound velocities and, from these, the elastic constants of heterogeneous substances.

B. Schuil, Holland

519. Volt, S. S., Transition of spherical sound waves from a moving medium into another medium moving at a different speed and having differing characteristics (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* 92, 3, 491-493, Sept. 1953.

Two semi-infinite fluid media having different acoustic properties are contiguous at the horizontal plane $z = 0$ and move parallel to this plane at velocities different in magnitude and direction. A point source of harmonic waves is located in the upper medium at $z = h$. Author develops integral equations for the acoustic potentials of direct and reflected waves in upper medium and refracted waves in lower medium.

W. W. Soroka, USA

520. Callaway, D. B., and Hall, H. H., Laboratory evaluation of field measurements of the loudness of truck exhaust noise, *J. acoust. Soc. Amer.* 26, 2, 216-220, Mar. 1954.

Simple loudness judgment tests were performed by a jury of 15 observers on the recorded noises of approximately 100 highway trucks. The loudness of the noises calculated by a modification of the equivalent tone method proposed by Beranek and co-workers ranges from about 20 to 200 sones. Observers were instructed to rank the noises in six loudness classes and were allowed to listen to a sample of class 1 and class 6 after each 20 recordings. The calculated loudnesses were then divided into six classes with class limits set by a 40% loudness increase per class. Although the subjective tests were conducted with no elaborate controls, a correlation coefficient of 0.94 was found between the average judgment of the group and the calculated loudness class. The correlation coefficient between average judgment and total sound pressure level was 0.78, whereas the correlation coefficient between the average judgment and the level on the A-network of the sound level meter was 0.83. Experimental techniques and the capabilities and limitations of the loudness-calculation methods are discussed.

From authors' summary

521. Keller, J. B., Finite amplitude sound produced by a piston in a closed tube, *J. acoust. Soc. Amer.* 26, 2, 253-254, Mar. 1954.

The problem stated in the title is solved for a gas with $\gamma = -1$ by the method of a previous paper [AMR 6, Rev. 3233]. First an arbitrary piston motion is considered. Then more detailed results are given for the sinusoidal case.

From author's summary

522. Subrahmanyam, S. V., Temperature dependence of ultrasonic velocity in plastics, *J. chem. Phys.* 22, 9, 1562-1563, Sept. 1954.

Soil Mechanics, Seepage

(See also Revs. 391, 392, 418)

523. Holmes, J. W., The movement of water in unsaturated soils; Trollope, D. H., A note on the physical aspect of cohesion; Aitchison, G. D., The physical condition of the soil as a modifying factor in the measurement and interpretation of shear strength; Birrell, K. S., Some physical properties of New Zealand volcanic ash soils; Trollope, D. H., The basic law of

shear strength; Turnbull, J. McN., Shearing resistance of soils; Glynn, D. F., Triaxial compression testing of soils; Fleming, H. D., Undrained triaxial compression tests on a decomposed phyllite; Newland, P. L., and Allely, B. H., Further evidence of increase of shear strength with depth provided by vane tests on a recent deposit of soft clay; Murphy, V. A., Penetrometer and vane tests applied to railway earthworks; Speedie, M. G., A note on the application of shear test results to structural computations; Loxton, H. T., McNicholl, M. D., and Bickerstaff, I. S., Procedures for determining the California bearing ratios of soils in unsaturated conditions; Beavis, H. M., Results of tests on experimental flexible pavement for 75,000-lb wheel loads over soft clay—Adelaide Airport, South Australia; Gawith, A. H., The use of in-situ shear tests in the design of flexible pavements; Trollope, D. H., Limiting factors in the design of structural foundations, *Proc. First Australia-New Zealand Conf. Soil Mech. and Foundation Engng.*, Univ. of Melbourne, June 1952; Carlton, Victoria, Melbourne Univ. Press, 248 pp.

The articles presented at this conference can be grouped under the following major subjects:

(1) A theoretical treatment of cohesion and soil shear strength. Cohesion is discussed in terms of molecular attraction within the adsorbed layers and the soil shear strength is related to fundamental soil properties.

(2) The practical application of laboratory shearing resistance data in the design of dams, embankments, foundations, and in other soil design problems. Laboratory test procedures are given and the various factors which influence shear data are discussed.

(3) The field use of in-situ shear tests for design purposes. Methods discussed include the CBR, penetrometer, and vane shear tests.

(4) The moisture movement in unsaturated soils and the resultant changes in soil strength and volume. This study has become especially important in the design of structures on heaving clays.

(5) Special laboratory studies on several volcanic origin soils. Tests include compaction, consolidation, and triaxial compression. The emphasis on practical application of test data and the use of in-situ methods for the determination of bearing and strength characteristics appears desirable. The description of test procedures, including modifications of United States and European methods, permits the reader to evaluate data and results much better.

L. A. DuBose, USA

524. Mkhitarayan, A. M., Calculation of seepage through earth dam provided with cut-off wall and toe underdrainage (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* 15, 169-176, 1953.

Some problems of steady seepage have been solved for conditions of horizontal boundaries of the pervious layer. It has also been shown that similar seepage problems, involving curvilinear boundaries of the pervious layer, are analogous with regard to discharge to the problems with horizontal boundaries. Making use of this analogy the author outlines a solution for the amount of seepage flow through underground with curvilinear boundaries and involving a vertical cut-off wall and a toe underfilter.

A. Hrennikoff, Canada

525. Shield, R. T., Plastic potential theory and Prandtl bearing capacity solution, *J. appl. Mech.* 21, 2, p. 193, June 1954.

Author shows that not only is the Prandtl bearing capacity of an infinite strip load on a c, ϕ soil an upper bound for the collapse value of the average pressure [AMR 6, Rev. 3592], but it is also a lower bound, and therefore the true value of the average pressure.

R. E. Gibson, England

526. Button, S. J., The bearing capacity of footings on a two-layer cohesive subsoil, *Proc. Third Inter. Conf. Soil Mech. Foundation Engng.*, Aug. 16-27, 1953, vol. I, 332-335.

Bearing capacity factors— N_c in $q = c_1 N_c$ —have been determined for a long strip footing of width $2b$, which is resting on a soil layer with thickness d and cohesion c_1 , underlain by a very thick layer with cohesion c_2 , and with $\phi = 0$ for both layers. The bearing capacities are determined by assuming a single circle of sliding for both soil layers and application of the method by Fellenius. The results are presented in a diagram with values of N_c for the ratio c_2/c_1 varying from 0 to 2.6 and the ratio d/b from 0 to 3. Another diagram indicates conditions, and corresponding values of N_c , for which the most dangerous circle of sliding is tangential to the lower soil layer. A third diagram presents values of N_c in case the cohesion in the upper soil layer varies linearly with depth from c_1 to c_2 . In answer to comments by the General Reporter, M. Buisson, the author demonstrates in his closing discussion [vol. 3, p. 155] that replacing a single circle of sliding with an arch composed of circles with different radii in the two soil layers has very little influence on the results when c_2 is greater than c_1 , but causes smaller values to be obtained of N_c when c_2 is smaller than c_1 .

M. J. Hvorslev, USA

528. Arons, A. B., and Kientzler, C. F., Vapor pressure of sea-salt solutions, *Trans. Amer. geophys. Un.* 35, 5, 722-728, Oct. 1954.

529. Baxter, D. C., A review of radiation scattering methods for measuring cloud droplet size, *Nat. Res. Council. Canad. Rep.* MD-40, Apr. 1954.

The fundamental aspects of radiation scattering from spherical particles are reviewed and used as a background for the study of various systems for the measurement of particle size in natural clouds, a parameter of interest in cloud physics and aircraft icing work. Corona, rainbow, and polarization methods are discussed but are considered hardly suitable. Radar scattering methods have certain advantages and are undergoing extensive development elsewhere, but the equipment is costly and analysis complex. A light transmission method can be used to give median volume size if combined with a liquid water content meter and if allowance is made for size spectrum. The photographing of the droplets in situ yields mean size and spectrum and could be further pursued, but recognition is needed of the basic problems to be overcome.

From author's summary

Geophysics, Meteorology, Oceanography

(See also Rev. 514)

527. Abdullah, A. J., On the dynamics of hurricanes, New York, New York University Press (Meteorological Papers 2, no. 2, Sept. 1953), 43 pp. \$2.

Part I: The eye of the hurricane. Author attempts to explain the existence of eyes of hurricanes by hydrodynamical considerations. Neglecting frictional forces, earth's rotation, vertical accelerations, and translation of storm and assuming hurricane is a Rankine vortex, author presents a hurricane model which must have an eye. The equations are derived for an equivalent three-layer incompressible atmosphere with the vortex in the lowest layer. The radius of the eye and the critical radius (separating regions where the local wave velocity is greater or less than the flow velocity) are computed. Also the funnel shape of the eye is deduced. A numerical example shows good agreement with observations of young storms. The above leads to an eye appreciably warmer than the surroundings, and author discusses case where warm air does not reach the ground, the likely case of a mature storm moving inland. Author also discusses validity of hyperbolic wind law.

Part II: The vibration of a hurricane. Author explores the ideas that the bandlike structure of some hurricanes may be due to inertia waves generated by free oscillations. Friction, motion, Coriolis force, and compressibility are neglected as are also basic vertical motions. The flow is assumed to be in solid rotation near the center and to follow the hyperbolic law outside. The atmosphere is considered barotropic. Two cases of natural oscillation are found: long period, $T >$ half the rotation period, and short period, $T <$ half the rotation period. The normal modes of the long-period vibrations are computed and it is suggested that the quasi-circular bands sometimes observed belong to this case. The walls of the eye of the hurricane are attributed to the single permissible mode of the short-period vibrations. A qualitative discussion of the spiral band sometimes observed is also given.

Reviewer feels that attention should be called to a similar treatment of the same problem by A. Kasahara [AMR 7, Rev. 979], in which the stability of the atmosphere is treated.

W. P. Elliott, USA

530. Benton, G. S., The occurrence of critical flow and hydraulic jumps in a multi-layered fluid system, *J. meteor.* 11, 2, 139-150, Apr. 1954.

In a multi-layered incompressible fluid flow, the energy transfer and momentum transfer are local minima at critical flow. In this multi-layered system, momentum and energy are insufficient to specify conditions downstream of a hydraulic jump when all of the upstream parameters are known. When momentum and energy are abstracted by function in the two-layer case, the flow is predicted to change to a flow with a derived relationship between the two fluid depths but not to a critical flow.

J. C. Freeman, USA

531. Lettau, H., Notes on the transformation of mechanical energy from and to eddying motion, *J. Meteor.* 2, 3, 196-201, June 1954.

The equations of mechanical energy of total, mean, and eddying motions are derived and discussed. It is shown that, in general, no term of these equations can directly be interpreted as representing the rate of transformation of mechanical energy of mean motion to mechanical energy of the eddying motion. Observational evidence is discussed, showing that the prominent energy transformations in the atmospheric boundary layer stem from the work done by the pressure-gradient force and from the viscous dissipation of energy. The eddy flux of energy of the mean motion and the divergence of this flux act as an intermediary agent between the prominent sources and sinks of energy. A characteristic of the atmosphere is the possibility of "kinetic-energy cycles," or two-way conversions in which the disturbance can feed into the energy of the mean motion, in contrast to the "energy cascade" from mean to eddy energy of wind-tunnel turbulence.

From author's summary by L. Machta, USA

Lubrication; Bearings; Wear

532. DuBois, G. B., and Ocvirk, F. W., The short bearing approximation for plain journal bearings, First Ann. ASME-ASLE Conf., Baltimore, Md., Oct. 1954. Pap. 54-LUB-5, 20 pp.

Method is presented which eliminates use of leakage factors for analysis of hydrodynamic journal bearings with length-

diameter ratio less than one. Suggested method of estimating maximum bearing operating temperature is included.

E. F. Macks, USA

533. Newkirk, B. L., and Lewis, J. F., Oil film whirl—An investigation of disturbances due to oil films in journal bearings, First Ann. ASME-ASLE Conf. Baltimore, Md., Oct. 1954. Pap. 54—LUB-4, 12 pp.

With three rotors and five bearings, tests have been run with oil at various viscosities to determine conditions defining a range of stable operation with cylindrical journal bearings at speeds above twice critical speed. It is concluded that short bearings, rather large clearance ratios, and moderate unit bearing loads favor a wide range of such stable operation, up to more than five times critical speed. Slight misalignment resulted in a remarkable increase of the range. After discussion of historical background and consideration of recently reported findings that seem to be at variance with those reported here, it is suggested that two basically different phenomena are involved, to which the terms "oil whip" and "oil-film whirl" have been applied indiscriminately. Results of a large number of runs under which the whirl was impending (the border line of instability) are presented in two tables.

From authors' summary

534. Weber, C., and Saalfeld, K., Lubricating film between rolls with deformation (in German), ZAMM 34, 1/2, 54-64, Jan./Feb. 1954.

By modification of the known theoretical solution for the load-carrying capacity of a fluid film between rigid rotating rolls, a theoretical estimate is made of the effect on load-carrying capacity and frictional drag of the slight elastic deformation of the rolls due to the fluid pressure, using results previously obtained by Weber [ZAMM, 30, 240-242, 1950] for the deformation of a half plane under any normal pressure distribution. Solution is derived both for viscosity $\eta = \text{const}$ and for $\eta = \eta_0 e^{\beta p}$, but is not valid for loads so large that the Hertzian pressure distribution for two rolls in contact is approached. No reference is made to experimental work.

G. D. S. MacLellan, England

535. Hamer, J. P., Tutwiler, T. S., and Weisel, C. A., Lubricating oil requirements of the modern automotive engine, ASTM Bull. no. 198, 70-76, May 1954.

After a brief discussion of modern engine design and its effect on oil consumption, authors point out desirable characteristics of a good engine oil. These include low volatility, high viscosity index, low pour point, and detergent-inhibitor additives. An oil of low viscosity at low temperature having a high viscosity index is considered to provide starting ease as well as lower friction loss and better fuel economy in the normal operating range. Data are presented to illustrate these points. It is suggested that the lower viscosity oils result in less engine wear, presumably because the lighter oils flow more readily to the friction areas in the engine. The function of special polymer viscosity index improvers is also discussed.

C. D. Strang, Jr., USA

536. Claypoole, W., Friction in a close-contact system, First Ann. ASME-ASLE Conf., Baltimore, Md., Oct. 1954. Pap. 54—LUB-6, 13 pp.

An attempt is made to clarify the terms "clean" and "smooth" as associated with the surface condition of test specimens used in investigations of frictional phenomena. A "practical model" of a

close-contact friction system is set up and its behavior analyzed under specified operating conditions. The ratio: real/apparent areas of contact between common metal surfaces pressed together cannot exceed a (relatively small) limiting value, since an oxide film is a permanent feature of the interface and cannot be squeezed out. The coefficient of static friction in tests made under low-load conditions is significantly reduced if any mechanical disturbance, even of low intensity, is permitted to reach the friction-contact spot. The coefficient of friction between diamond and either glass or hard steel is abnormally low. No abrasive damage results from rubbing together under exceedingly high local pressure. Tests were made in air and with no lubricant.

From author's summary

Marine Engineering Problems

(See also Rev. 483)

537. Troost, L., and Zakay, A., A new evaluation of the Lucy Ashton ship model and full scale tests, Inter. Shipbldg. Progr. 1, 1, 5-9, 1954.

B.S.R.A. experiments with a ship and six geometrically similar models [AMR 5, Rev. 3604; 6, Rev. 3620] are expanded by the authors to two further models 4 and 6 ft long. Correlation of results in Telfer's manner by use of Troost-Lap formula (derived from Nikuradse's smooth pipe results, bypassing the flat plate, to viscous drag extrapolator for three-dimensional turbulent flow including viscous "form effects"; Bull. SNAME VIII, 2, June 1953) instead of Schoenherr formula, gave results closer to the average mean line through the test points. From these evaluations, authors suppose separation of turbulent boundary layer to occur nearer to the stern for small models with lower Re numbers than for large ones; therefore, also, an increased wave resistance for the large models is to be expected.

H. Thieme, Germany

538. Hughes, G., A note on friction resistance with special reference to ship forms, "Mémoires sur la mécanique des fluides," Publ. sci. tech. Min. Air, Paris, 135-141, 1954.

Brief summary of results of tests with smooth friction plates towed vertically. The frictional line for two-dimensional flow is obtained by extrapolation on a base of the aspect ratio of the test surfaces. The line is steeper and shows less specific resistance at high Reynolds numbers than the Prandtl-Schlichting line.

H. W. Lerbs, USA

539. Van Manen, J. D., Recent data on cavitation criteria, Inter. Shipbldg. Progr. 1, 1, 39-47, 1954.

The results of the author's vortex theory systematic screw series are checked on Burrill's empirical cavitation diagram, and good agreement is shown within the limits given for lightly and heavily loaded propellers. The new cavitation criteria, however, show a definite dependence on pitch ratio. Therefore, new and simple cavitation charts are presented for screws with 2, 3, 4, and 5 blades in a uniform wake, and for 4-bladed screws also in a standardized radially variable wake. From these charts the minimum developed blade area ratio required for freedom of cavitation can be obtained for given pitch ratio and cavitation index at the 0.8 R blade section, with a minimum amount of work. An example of a calculation is given.

L. Troost, USA

540. Szebehely, V. G., On slamming, European Shipbldg. 4, 3, 80-85, 1954.